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Dorothea Jansen
Insa Pruisken *Editors*

The Changing Governance of Higher Education and Research

Multilevel Perspectives

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Multilevel Perspectives

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Preface and Acknowledgements

In May 2001, a group of scholars from Europe met at a conference on "International Competitiveness and Innovative Capacity in Universities and Research Organisations" at the German Institute for Public Administration in Speyer. The conference which was supported by the German Research Foundation aimed to discuss the reforms and changes in the governance of the German public research sector in the context of the reforms under way in the other European countries. This was the starting point for the establishment of the research group "Governance of Research" who set out to analyse the German higher education and research system from a comparative and interdisciplinary perspective. In summer 2003, the German Research Foundation approved of the funding for the joint research programme, and in 2006 the funding was renewed. Today the research group comprises six projects complemented by a project on the provision of bibliometric data analysis and the speaker's coordination project. Funding by the German Research Foundation is gratefully acknowledged.

This is the third joint publication of the group (*cf.* Jansen 2007, 2009) which focuses on the question of how disciplinary differences interact with the new forms of governance of research and increasingly get implemented into the German research system.

This volume would not have been possible to put together and coordinate for me without the help of Tobias Semmet and Insa Pruisken who supported me as the speaker of the group. Thanks also go to Martina Grammes who had a look at the correct use of the English language. We would also like to thank Jesse Paul Lehrke for his valuable grammatical, stylistic and general editorial assistance.

Speyer, Germany — Dorothea Jansen
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April 2014

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Chapter 1
Introduction: The Changing Governance of PhD Education and Research

Multilevel Perspectives

Insa Pruisken and Dorothea Jansen

1.1 Transforming European Science Systems

Since the mid-1990s a vast and still growing body of literature concerning the changing nature of governance of higher education and research has emerged. Scholars have observed a "wind of change" (Neave and van Vught 1994), a "dramatic restructuring of higher education" (Reed et al. 2002), and an "increasing reform pressure" (Jansen 2007) which they describe as "remarkable" (Braun and Merrien 1999), "fundamental" (Kehm and Lanzendorf 2006: 9), "major" (Ferlie et al. 2009) or "profound" (Krücken et al. 2007: 7). These changes in the governance of research can be briefly summarised as the following:

Firstly, changes can be observed that occur in the relationships between universities (and public research organisations) and governments. These changes are characterised by a shift from direct state intervention to a "steering from a distance" style of state intervention. Such changes have been implemented in universities within the framework of New Public Management (NPM). Comparing different European countries, two models of system level governance can be distinguished. On the one hand we observe the governance model that emerged in Continental Europe, which is based on the idea that the university or the public research organisation is a state institution. On the other hand, the Anglo-Saxon model of governance introduced elements of New Public Management (NPM) in the early 1980s (Reed et al. 2002). The general assumption of this model is that the state has to steer

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at arm's length by implementing a quasi-market in which higher education institutions and research organisations (rather than individual scientists) compete for students, research funds and reputation.

Secondly, these changes at the level of governance regimes (Lange and Schimank 2004) influence the authority relations at the organisational level (Whitley et al. 2010). Public research is expected to perform a "third mission" and is no longer seen as a natural source of wealth and progress (Krücken and Meier 2006). The changing role of the state in directing universities and research organisations and the expectation that universities become an "agent in managing [...] commercialisation processes" have encouraged the view "that universities are becoming more like firms in developing distinct entrepreneurial capabilities and some strategic autonomy" (Whitley 2008). Krücken and Meier (2006) point out that in the process of "turning the university into an organizational actor" four main elements can be distinguished: accountability, the definition of goals, the elaboration of formal structures and the rise of the management profession. So that universities and research organisations can develop into entities which can be held responsible for what they do and which are able to build strategies and research profiles, NPM instruments such as target agreements, evaluations, and so forth have been implemented. Boer et al. (2007) provide an analytical tool, the "governance equalizer", in order to analyse differences in the changes in governance within different European countries. They show a clear move towards the management model in all four countries included in their study (Germany, Austria, The Netherlands, and England) (cf. detailed analyses Kehm and Lanzendorf 2006, Schimank and Lange 2009).

Thirdly, and contemporaneous to the above developments, the European Union has strengthened its role in Research, Technology & Development (RTD) policy (cf. Jansen and Semmet 2012). Ever since the Commission's communication entitled "Towards a European Research Area" the European influence on the national level has become more important as it strives for the integration of national research policies in order to overcome the "European Paradox". The explicit call that project proposals submitted to the EU demonstrate interdisciplinarity, internationality, pan-European collaborations and, in particular, commercialisation of research results stems from the fact that RTD policy is seen as a major contributor to the economic competitiveness of the European Union. New forms of governance are emerging, creating new horizontal and vertical links between European and national actors (e.g. joint calls by national funding organisations or the establishment of the European Research Council).

The objective of this conference volume is twofold: On the one hand we strive to empirically investigate how governance is changing on the different levels (system level, organisational level and shop-floor level, including PhD education). What are the intended and unintended consequences of these changes? On the other hand, the volume aims to study the role of the European Union, analysing the newly established instruments such as the ERC, ERA-nets and technology transfer activities, while also taking into account the multilevel governance systems in research and higher education policy.

1.2 Governance as an Analytical Perspective

To understand and analyse the empirical effects of the described ongoing developments the research group "Governance of Research"[1] has developed an appropriate analytical framework. Jansen (2010) argues that, at the macro-, meso- and micro-level of the science system, the so-called "old" forms of university governance mix or interfere with the new forms of organisational governance. Academic self-governance, hierarchical self-management and collective action supported by scientific entrepreneurs may collide or be mixed. Intellectual coordination among peers via competition for reputation at the micro-level may collide with research priorities set at the organisational level. Thus, these governance forms interact in a complex way and lead, ultimately, to scientific performance which can be characterised by the dimensions research, graduate teaching and "third mission".

Resources (money, personnel and time) and competences such as competitiveness, the capacity for innovation, decision making abilities and strategic abilities are understood as intervening variables. These throughputs are affected by governance changes and influence research in various ways: regarding how research is organised, the size of research groups and teams, and how they react strategically to their environment. Resources and competences expand or limit the freedom of researchers to set research agendas of their own choosing (for a detailed account of the theoretical model and the definition of the term "governance" see Jansen 2010). The arrow "empirical and normative evaluation of assumed effects" refers to the objective of the research group: assessing empirically the effects of new forms of governance on the level of performance (Fig. 1.1).

In addition, when analysing the European science systems in terms of governance dimensions it becomes apparent that these modes of coordination interact in a multilevel governance system (cf. Benz 2007): the macro-level of the state and the science system, the meso-level of organisations and interorganisational relationships, and the micro-level, which is the shop-floor level of research. Analysing the different levels in detail we find a multitude of actors involved, all of which engage with and influence one another. These include:

- at the level of direct state intervention, national governments and the European Commission (as well as the "Länder" in Germany) which fund universities and

[1] The research group was established in 2003 and was funded by the German Research Foundation (DFG) between 2003 and 2010. The group was set up by seven different research projects and one coordination project. This is the third joint publication of the research group. The first book on "New Forms of Governance in Research Organizations – Disciplinary Approaches, Interfaces and Integration", also published with Springer, outlined the interdisciplinary approach of the group. The second book "Governance and Performance in the German Public Research Sector: Disciplinary Differences", published in the Higher Education Dynamics Series, focused on governance and the effects on different disciplinary fields. This volume is an outcome of the final conference of the group. The conference took place in March 2010. The members of the research group presented their final results – complemented by scientists outside the group: Andrea Kottmann, Arie Rip and Tembile Kulati, Christine Musselin, Andrea Bonaccorsi, Philippe Larédo, and Christine Godt. We thank the German Research Foundation for funding and the complementing authors for their contributions.

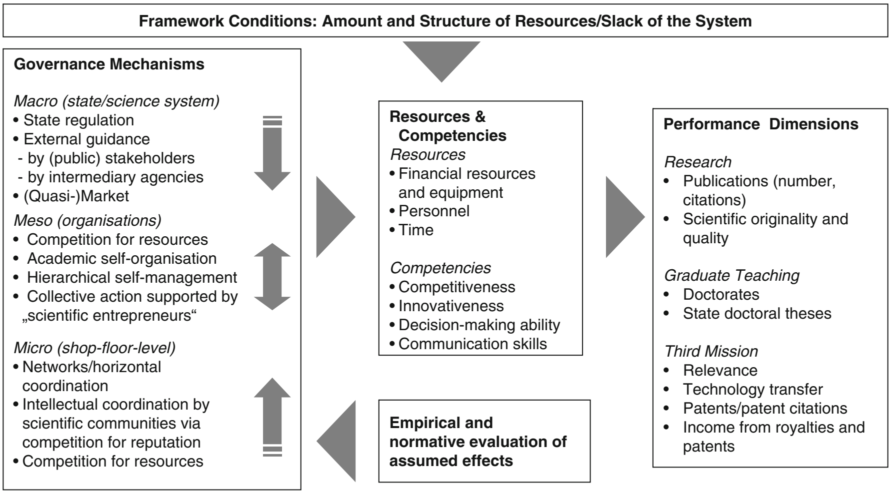

Fig. 1.1 Analytical framework

public research organisations and delegate competencies to intermediary agencies such as the DFG, ANR, British Research Councils, and agencies established by the EC (ERC, Joint Technology Initiatives) which fund research groups, universities and research organisations based on mostly competitive peer-review procedures;

- at the meso level, research organisations such as the German Max-Planck-Gesellschaft, Helmholtzgemeinschaft or the French CNRS with their own institutes and evaluation procedures;
- at the meso level, universities and (multi) disciplinary public research organisations, which have within them a mix of managerial and academic self-governance;
- stakeholders from industry and society which advise and evaluate universities and research organisations, as well as fund research and research collaborations
- scientific or epistemic communities, with their discipline-specific characters, which set research priorities and organise the disciplines;
- at the micro level, research groups and PhD-students working in various different research settings (research projects, Research Training Groups).

The multilevel governance approach assumes that in a multilevel governance system actors depend on each other and have to coordinate their actions (Benz 2007). We expect that, in the process of integrating European research policy, decision-making has become much more complex. The different levels affect each other and produce unintended effects. New concepts of governance such as Mode 2, Triple Helix and New Public Management are being promoted by intermediary agencies and European and national policy makers and affect, in particular, the organisational level and the shop-floor level of research. On the other hand, researchers are exerting influence on research policy making (in high-level groups of the European Commission and through the peer review procedures of national funding agencies and the ERC). Private actors have come to be involved and act as collaboration partners or give advice to universities, research organisations or ministries. The emerging question is how these changing institutional conditions on the different levels contribute to the formation of new search regimes (Bonaccorsi 2008) and/or to the production of "frontier research" (EC 2005; Larédo this volume) or "risky research" (Enders et al. this volume; Jansen et al. this volume) or improve research performance in general.

Research questions set out for this volume are:

Part I

1. What are different effects of the traditional PhD education model in Germany and the newly introduced "Research Training Groups"?
2. How does the governance instrument "Research Training Groups" influence the performance of graduate students?
3. What are the conditions for scientific success of graduate students?
4. What is the role of disciplinary differences? Do the natural sciences need other governance instruments than the social sciences or humanities?

Part II

1. How do the NPM reforms influence the shop-floor-level of research?
2. How do institutions of science and search regimes fit together?
3. What are differences between countries and disciplinary fields?

Part III

1. What is the formal structure of the European Research Council? How is it set up?
2. How should an organisation aiming at promoting "frontier research" be designed?
3. How can European governance instruments be described from a public law perspective? What are consequences for the multi-level-system and national governance structures?
4. How can European governance instruments be described from a private law perspective? What are the effects of changing property rights regulations on public research?

1.3 Introduction to the Contributions

Part I focuses on the shop-floor level of research by studying the governance of PhD education and its effects on research outputs and the time requirements for a doctorate. The Continental Model of PhD education has long been criticised as being inefficient and less competitive than doctoral education in England or the US. The German Research Foundation, for example, claims that PhD students should be trained in a more interdisciplinary environment, where research is practised in a collaborative rather than in an individual mode. Science-policy makers believe that interdisciplinary research is more problem-orientated, following what Gibbons et al. describe as "Mode 2" knowledge production. More competitive forms of research are expected to attract the best students, matching them with the best researchers for training them. Additionally, it is expected that a more structured research environment, such as through Research Training Groups, will help PhD students to attain their doctorates in shorter time.

Birgit Pferdmenges, *Kerstin Pull* and *Uschi Backes-Gellner* apply a human resource perspective and pose the question of whether or not more interdisciplinarity and internationality among RTG students does in fact increase RTG performance. Drawing from literature on team composition and team performance they hypothesise that team heterogeneity may have positive effects on team performance if team members possess distinct knowledge bases or abilities that are relevant for the production process. However, on the other hand, team heterogeneity may also negatively affect team performance because communication between team members could be hampered, conflicts may arise and group cohesion reduced. They expect that different forms of heterogeneity (interdisciplinarity and internationality) and types of disciplines have effects on performance. By comparing 86 RTGs funded by the German Research Foundation and analysing them with the seemingly unrelated regressions (SUR) model they reach the conclusion that "the interdisciplinarity of RTG students has on average positive effects on the RTG performance in the humanities and social sciences. The internationality of RTG students seems to have on average negative effects on the RTG performance in the humanities and social sciences. The relationship between the study field heterogeneity and the doctoral completion rate is hump-shaped (for the natural and life sciences)."

The contribution of *Andrea Kottmann* addresses the same research subject: Research Training Groups funded by the German Research Foundation. She analyses whether the RTGs are more efficient than other forms of doctoral training. The analyses builds on a large scale survey undertaken in 2005 which includes 8,450 former members of RTGs as well as PhD holders who have graduated in a traditional doctoral training setting. Kottmann compares the time required to gain the doctorate as well as integration into collaborative research and integration into the larger academic community. She also analyses the influence of individual characteristics, characteristics of the training and the influence of the discipline (arts and humanities/social sciences, life sciences, natural sciences and engineering). She concludes that being less integrated into the research interests of the supervisor lengthened the time to gain the doctorate for both groups. For students outside the RTGs, being less integrated in exchanges/cooperative endeavours with other experienced scientists lengthened the time required for the doctorate. Kottmann states that the training conditions in the RTGs did not contribute to a shortening of the time needed to attain the doctorate compared to traditional doctoral training. Moreover, doctoral students inside the RTGs do not publish more than doctoral students outside RTGs.

Peter Schneider and *Dieter Sadowski* refer to the "Governance Equalizer model" (Boer et al. 2007) and analyse the interplay of the five governance dimensions and their effect on successful academic placement. To assess the influence of the implementation and outcomes of new forms of governance on PhD education they distinguish three governance regimes: Continental Europe, England and the US. Their sample includes 5 departments in England, 13 departments in Continental Europe and 8 departments in the US. Between 2005 and 2008 they conducted semi-structured in-depth interviews with 81 key academic and administrative persons within the respective departments and analysed the interview statements using "fuzzy set Qualitative Comparative Analysis". In a nutshell, they conclude that the dimension "competition" is the only necessary condition which can explain the successful academic placement of PhD students who have attained their doctorate. A competitive environment in which PhD students are trained to research and raise funds seems to play a pivotal role.

In line with the approach of Schneider and Sadowski, the contributions of **Part II** compare or analyse governance regimes and link them to the shop-floor level of research and to authority relations on the organisational level. The contributions of Enders et al., Rip/Kulati and Jansen et al. look at research management and/or research as the dependent variable, analysing the effects of governance changes and reforms as independent variables. Bonaccorsi changes the research perspective and asks how institutions of science and different search regimes may fit together, assuming that fast growing "new sciences" need more competitive and flexible institutional conditions than slower growing and established "old sciences".

Jürgen Enders, *Barbara Kehm* and *Uwe Schimank* analyse the effects of the New Public Management reforms on academic research in four European countries: Germany and Austria as latecomers to NPM and England and The Netherlands, where the reforms were implemented much earlier and more rigorously. They studied 16 groups from the four countries by comparing two disciplines: red biotechnology and medieval history. They conducted a first round of interviews in 2004/2005 and a second one in 2008/2009. In their analysis, they focus on the question of how NPM has affected certain characteristics of academic research such as publication strategies, quality of research, the choice of research topics, the balance of mainstream versus risky research, the balance of basic versus applied research, and the research/teaching nexus.

The main results reveal that, on the one hand, the increasing dependency of research on third-party funding has made it more difficult for researchers to build long-term research agendas (in particular in medieval history). On the other hand, increasing competition and control in practice rely on traditional academic criteria and mechanisms. Hence, New Public Management is not likely to strengthen the relevance and user orientation of academic research. Because third-party funding relies on peer review, NPM fosters the professional elites. In addition, Enders, Kehm and Schimank conclude that by separating the financial and organisational support of research and teaching, NPM leads to a decoupling of these core operations of academic work.

While Enders et al. focus on the shop-floor level of research, *Arie Rip* and *Tembile Kulati* take an organisational perspective and investigate what sort of (intra-university) multilevel research management manifests itself. Regarding research management in the university as a dependent variable they analyse the effects of vertical (intra-organisational relationships) and horizontal (inter-organisational relationships) pressures. Considering the type of university as an intervening or mediating variable they distinguish between “classical elite universities”, “enterprising universities” and “niche occupying universities”. With this analytical approach they study the multilevel patterns and dynamics in six research universities, comparing universities in South Africa and the Netherlands.

Their findings reveal that differences in the research management of the three types of universities are minor. National differences between Dutch and South African universities can be observed and explained by different administrative cultures. They suggest that the “modernist vision” of the university as an organisational actor may have to be replaced by the vision of a “heterogeneous university complex”. Such a vision would make it easier for research managers to escape the “stranglehold” of “one size fits it all” – approaches, as discussed in the next chapter.

Dorothea Jansen, *Regina von Görtz* and *Richard Heidler* look into the emerging mixture of governance mechanisms and their influence on resources and competencies as well as on the research performance of research groups at the shop-floor level. They ask whether and how changes in the governance pattern effect research groups’ choices with respect to lines of research and research partners or network building. The contribution addresses the complexity and pitfalls of indicator systems and the dynamics of competition for third-party funding. In addition, the influence of science-policy makers, funding agencies and organisational leaders on collaboration strategies, network building and network structure are explored. The study is based on panel data gathered from 75 to 77 research groups from the fields of astrophysics, nanoscience and economics. The data thus represents social sciences and natural sciences, as well as basic and applied research fields, for three points in time: 2004, 2006/2007 and 2009. The analyses show a variety of unintended effects by new governance structures on research. These unintended effects are most evident when simple incentive systems are implemented, ones which do not take into account the specific conditions of knowledge production such as disciplinary differences, third-party funding logics, the functionality of slack resources, and the contingency of network types in tasks and optimal structure. Incentive systems do indeed also show intended effects, but can have negative or unintended effects beyond a specific threshold, especially in some disciplines or institutional types.

Andrea Bonaccorsi brings in an institutional perspective from which he addresses the relatively permanent, or slowly changing, features of the way in which science is produced. Rather than asking how governance changes affect the micro and organisational level of research, he poses the question of how and in which way institutions of science and new search regimes fit together. By analysing the “institutions of science” in Germany he develops an explanation for why Germany “is not a world leader" in software- and biotechnology. He identifies five dimensions of institutions of science: creation of skills for research, recruitment and career of researchers, public funding of research, academic governance, and institutional complementarity. In fast growing and high-diversity fields, such as information technology and life science, the key institutional elements are mobility, fierce competition for students and academic staff, fast growth in funding and education curricula, and/or institutional flexibility at the boundaries. Bonaccorsi concludes that national systems whose institutions of science provide better conditions for meeting these requirements will perform better.

Part III focuses the emerging role of the European Union in national research policy. The European Union attempts to overcome fragmentation, compartmentalisation and the "European Paradox". For that purpose the European Commission has set up a number of new funding instruments which are analysed and described in detail by the following contributions. This part contains contributions from the perspective of jurisprudence (Groß/Karaalp, Pilniok nd Godt) as well as one more essayistic contribution by Laredo on the future role of the ERC.

Thomas Groß and *Remzi Karaalp* provide a legal analysis of the European Research Council (ERC). The central question of the contribution is whether the ERC's organisational structure and its rules of procedure are able to create trust in the evaluation of applications. For that purpose, Groß and Karaalp analyse the function of the ERC from a legal perspective. As with all national funding agencies, peer review is the basic mechanism for determining excellence. But they observe a strict separation between scientific tasks assigned to the Scientific Council and administrative tasks assigned to the ERC Executive Agency. This separation is unique to the context of the European Union and makes the ERC model incompatible with national models of research funding agencies. They conclude that the procedural safeguards for the evaluation process are best practice. However, the organisational structure should be modified in order to guarantee the complete autonomy of the ERC outside the statutes regulating Executive Agencies.

Philippe Larédo asks in his contribution whether the implementation of the European Research Council (ERC) provides a solution that can promote "Frontier Research" and overcome the "European Paradox". For that purpose, Larédo compares different concepts for promoting "frontier research" and "transformative sciences" as developed by European and American funding agencies. The US Department of Energy has set up an initiative which focuses on centres, Europe has created a new funding agency, the US National Science Foundation has proposed to include a new criterion in its panel, and the NIH (National Institute of Health) has established a new initiative based upon individual scientists. Laredo examines the role of organisational dimensions and different search regimes. Referring to research on the impact of peer review, he argues that peers foster mainstream rather than frontier research. Because peer review is the central method for determining excellence, Larédo is sceptically if the ERC can help to overcome the "European Paradox". He comes to the conclusion that the ERC should become the agency of agencies, which chiefly aims to cope with diversity in knowledge dynamics.

In his contribution, *Arne Pilniok* focuses on the changing European governance of national research policies and research funding, which are driven by the European Commission's objective to coordinate and integrate national research policies on the European level. Taking up the governance perspective he analyses which governance structures are used and established in order to integrate national actors into research policy and research funding within the European Research Area. In particular, he analyses firstly European policies, such as the open method of coordination in research policy, the mechanism of soft law (based on the coordination competence of the TFEU) and the coordination by committees. Secondly, he analyses European and national research funding instruments such as the ERA-Net Scheme and structures based on article 185 TFEU. In doing so he addresses problems of legitimacy and accountability that arise because of the chosen structures and modes.

Christine Godt describes in her contribution the changing governance of research from a private law perspective, focusing on the role of technology transfer at the European and national level. The contribution tracks the historic development of technology transfer; explores current structures on the European and the national level, such as the Framework Programme and the newly established Joint Technology Initiative; and discusses legal problems with regard to technology transfer. Godt describes and discusses rules of intellectual property rights and the role of technology transfer offices. These newly created entities at universities could be conceived of as intermediaries or "hinge-joints" which enable the multi-directional flow of knowledge and inspiration between "idle research" and industry.

In the last chapter, "Summary and Recommendations", we summarise and synthesise the results and outline some recommendations for science policy makers.

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Part I
Changing the Governance of PhD – Education: Effects on Research

Chapter 2
Composition and Performance of Research Training Groups

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2.1 Introduction

In the early 1990s, a new, more competitive oriented form of governance for PhD education in Germany was established: the so-called Graduiertenkollegs (Research Training Groups – RTGs). RTGs were introduced by the German Research Foundation (Deutsche Forschungsgemeinschaft) as a major intermediary in the governance of research in Germany. They are run by a group of cooperating researchers and include a study programme covering a set of doctoral and postdoctoral projects. The study programme is compulsory for the RTG students and is held to provide them with methodological skills and specialised knowledge in a particular field of research. The German Research Foundation grants fellowships to the RTG students as well as funds for travel expenses and equipment. Until March 2003, a grant consisted of an initial funding for a period of three years that could be renewed twice; since April 2003, a grant has consisted of a funding for 4.5 years, and this period can only be renewed once. At present, about 240 Research Training Groups are funded by the German Research Foundation (see DFG 2010; Unger et al. 2010).

Among the most prominent governance mechanisms used to steer the RTGs is the explicit call for interdisciplinarity and internationality by the German Research

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Foundation (see DFG 2008). While apparently hoping for positive effects of interdisciplinarity and internationality (with the call for interdisiplinarity being closely linked to the discussion on the increasing relevance of mode 2 research; see e.g. Jansen et al. and Laredo in this volume), surprisingly little is known on the outcomes of this kind of input-oriented external governance pushing in the direction of more interdisciplinarity and internationality which is further being promoted by an increasingly competitive model of PhD education (cf. Bonaccorsi in this volume) fostered by the introduction of RTGs: Will more interdisciplinarity and internationality among RTG students in fact increase RTG performance or not? In what follows we will shortly review the literature and then present first empirical evidence on the question.

2.2 State of Research

The impact of RTG composition on RTG performance has not been analysed as yet. In the light of the fact that the scientific environment proves to be increasingly important for knowledge production (see Carayol and Matt 2004; Stephan 1996), this would indeed seem surprising. The trend towards more collaboration in scientific work manifests itself – among others – in a well-documented increase in co-publications (see e.g. Rigby and Edler 2005: 785; Adams et al. 2005) and in authors increasingly acknowledging the help of others in their own work (Giles and Councill 2004: 17603 f.). Hence, we regard RTGs as shaping the relevant or at least one relevant scientific environment for RTG students, and in what follows refer to the general literature on (research) team composition and performance even though the performance of an RTG (as measured by the doctoral completion rate and by the scientific visibility of its students, see below) might not in general be regarded as being the outcome of a true team production process.

As far as studies on the relationship between research team composition and team performance are concerned, these are also few and far between and, moreover, they lead to contradictory results. E.g. Porac et al. (2004) study research cooperations on the analysis of ecosystems on the one hand and cooperations in the field of astrophysics on the other. While for the former, they detect a positive effect of interdisciplinarity on research output, for the latter they identify a negative one. The latter result is in line with the work by Jansen (2007) highlighting the potential problems of interdisciplinary research. Hollingsworth (2002), however, presents empirical evidence for a hump-shaped relationship between interdisciplinarity of research groups and their innovativeness. In light of the inconsistency of empirical findings, Porac et al. (2004: 675) conclude that "much more research is necessary" concerning research cooperations and alliances in order to better understand the relationship between research team configurations and performance (see Bell and Kravitz 2008: 301 for a similar claim).

Furthermore, what is true for research teams in particular is also true for the general question of team composition on team performance – in spite of a vast and growing body of literature. Accordingly, Harrison and Klein (2007: 1199) conclude their recent review on the subject, stating that findings on the relationship between team composition and team performance have been "weak, inconsistent or both".

From a theoretical perspective, these mixed empirical findings may be the result of two countervailing effects: (i) On the one hand and highlighted by the so-called resource perspective (see, e.g. Gruenfeld et al. 1996; Hambrick and Mason 1984; Jackson 1992; Thomas 1999), team heterogeneity may indeed have positive effects on team performance if team members possess distinct knowledge bases or abilities that are relevant for the production process. (ii) On the other hand, however, team heterogeneity may also negatively affect team performance because the communication between team members is endangered, conflicts arise and the group cohesion is reduced (so-called process perspective, see, e.g. Byrne 1971; McPherson et al. 2001; Pelled et al. 1999; Tajfel 1974, 1981; Turner 1975, 1987).

While the net effect of team composition on team performance hence remains unclear from a theoretical as well as from an empirical perspective, we hypothesise that it will (a) depend on the type of team heterogeneity (interdisciplinarity, internationality) and (b) on the disciplinary field (humanities and social sciences vs. natural and life sciences). While the latter hypothesis is motivated by our earlier study on the RTG performance in these two different disciplinary fields (see Unger et al. 2010), the former is based on an extensive body of literature concerning the potentially differing effects of functional as opposed to demographic heterogeneity: While internationality as a form of demographic heterogeneity is regularly argued to have a negative net impact on team performance, resulting from enhanced communication problems, the potential for conflicts and reduced group cohesion (see, e.g. Jehn et al. 1999; Pelled et al. 1999; Smith et al. 1994), the interdisciplinarity being part of the so-called functional heterogeneity is typically regarded as being net performance-enhancing at least as long as it is related to the team task. Moreover, functional heterogeneity is less likely to be linked to identity than demographic characteristics are and consequently less likely to cause social categorisation (see, e.g. Ancona and Caldwell 1992; Jehn et al. 1999; Pelled et al. 1999). Both theoretical claims, namely the potentially net performance-enhancing effect of functional heterogeneity as well as the potentially net performance-reducing effect of demographic heterogeneity are mirrored well in empirical studies (see, e.g. Hagedoorn et al. 2000; Cannella et al. 2008 for the former and Thomas et al. 1996 for the latter).

2.3 Data and Measures

Our empirical analysis is based on a data set of 86 RTGs funded by the German Research Foundation (DFG). It comprises all Research Training Groups from the humanities and social sciences and the natural and life sciences who are in their second funding period and who submitted an application for a third funding period to the German Research Foundation between October 2004 and October 2006 (see

Unger et al. 2010 for the details). 28 of the 86 RTGs in our data set belong to the humanities and social sciences, 58 RTGs belong to the natural and life sciences.

(a) *Dependent Variables: RTG Performance*
The performance of the Research Training Groups is measured by their scientific visibility (number of publications) and by the doctoral completion rate. Both are measured per funding year in order to control for varying RTG sizes and for varying degrees of student fluctuation among RTGs. While the doctoral completion rate is an obvious measure of the RTG performance, a measure of the scientific visibility is added in order to account for the fact that RTG students were established to train the next generation of researchers who should hence be introduced to the process of scholarly publication. When collecting the data, we counted all kinds of publications of RTG students: monographs, editorships, journal articles, book sections in edited books, conference proceedings, discussion papers, published abstracts, and reviews. We adjusted the publications according to the number of authors and allocated a fraction of 1/n to each author (see, e.g. Egghe et al. 2000: 146).[1] We decided to use all publications instead of just counting journal articles as an indicator for research performance for the following reasons: Firstly, the indicator "total publications" proves to be a good predictor of the German Research Foundation's decision to approve the application for a third funding period. As the decision to either approve or reject an RTG's application is based on the well-founded judgement of experts in the respective field, we are confident that the indicator "total publication" measures RTG performance. Secondly, by not only including journal articles we account for differing modes of publication (in the natural and life sciences, journals are the predominantly used publication outlet, whereas in the humanities and social sciences book sections represent the dominant mode of publication; see Unger et al. 2010). Finally, as we do not dispose of a comprehensive journal ranking including all the different journals from all the different subjects and subdisciplines covered in our data set, the main advantage of using an indicator of scientific visibility based on (appropriately weighted) journal articles only, was not an option.

(b) *Explanatory Variables: RTG Composition*
To capture heterogeneity, we calculate the widely used index of heterogeneity (Blau 1977). It is defined as

$$H = 1 - \sum_{i=1}^{n} s_i^2$$

with n representing the total number of categories of a variable, and s_i the fraction of team members falling into category i. We calculate Blau's index

[1] Whenever the number of co-authors was not specified in the research reports but the expression "et al." hinted at a joint production of publication outputs, we supplemented our data from the RTG research reports by information gathered from the internet.

concerning (i) the field of study and (ii) the nationality of the doctoral and postdoctoral students in an RTG. As fields of study we distinguish 22 different fields according to the ISCED; concerning the nationality of RTG students we distinguish nine cultural regions according to the classification by Huntington (1996). Afterwards the figures are normalised on the interval [0,1] (see Alexander et al. 1995: 1466).

2.4 Descriptives

As the descriptive statistics reveal, performance as well as heterogeneity vary considerably between the disciplinary fields and also between individual RTGs within one disciplinary field.

2.4.1 RTG Performance

Number of publications: Fig. 2.1 first displays the number of publications per funding year, both for the humanities and social sciences (left panel) and for the natural and life sciences (right panel). As can be clearly seen, in the RTGs from the humanities and social sciences the number of publications per funding year is on average considerably higher than in the RTGs from the natural and life sciences. This result is mainly explained by differences in co-authorships and the 1/n-count which reduces the publication count particularly for natural and life sciences with their traditionally long lists of co-authors.

Doctoral completion rate: Concerning the doctoral completion rate per funding year (Fig. 2.2), the picture is less clear: While the RTG with the highest doctoral completion rate per funding year belongs to the humanities and social sciences, the overall performance is higher in the natural and life sciences (with 20 out of 58

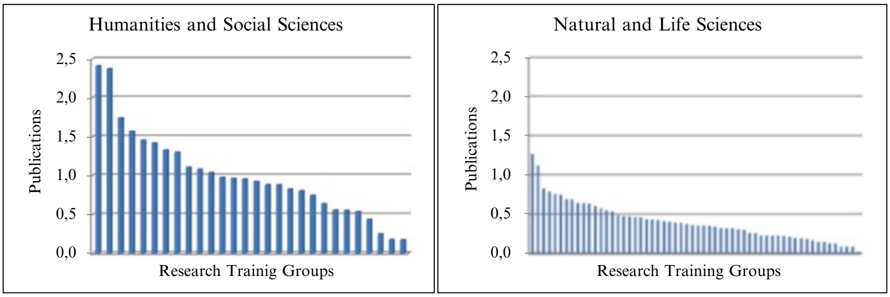

Fig. 2.1 No. of publications per funding year (Source: Own data)

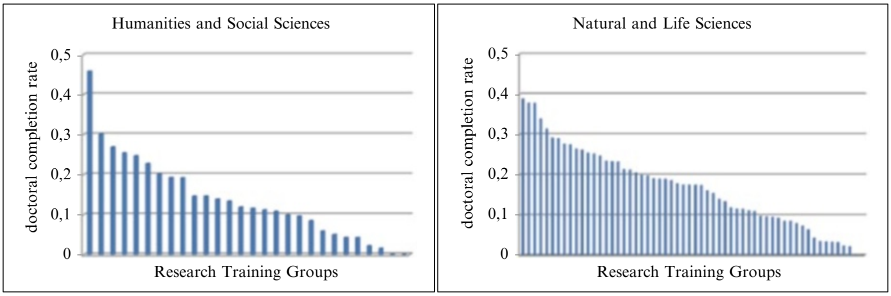

Fig. 2.2 Doctoral completion rate per funding year (Source: Own data)

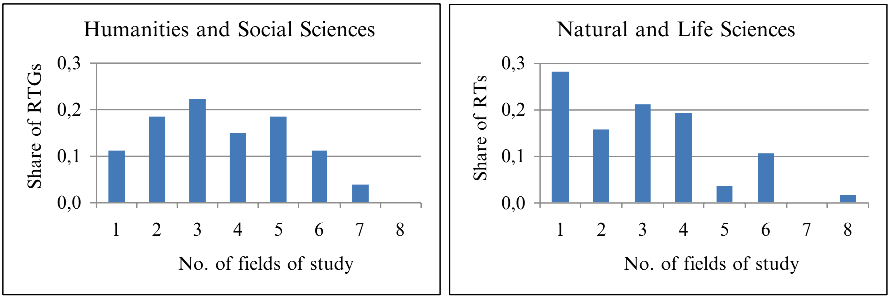

Fig. 2.3 Interdisciplinarity – no. of fields of study represented by the students in an RTG (Source: Own data)

RTGs having a doctoral completion rate per funding year of at least 20 %) and lower in the humanities and social sciences (with only seven out of 28 having a completion rate of more than 20 %).

2.4.2 RTG Composition

Interdisciplinarity: Our first dimension of heterogeneity concerns the question in how far an RTG is characterised by interdisciplinarity of its students. Figure 2.3 displays the shares of RTGs in the humanities and social sciences (left panel) and in the natural and life sciences (right panel) concerning the number of different subjects studied by their doctoral and postdoctoral members. The share of RTGs in the humanities and social sciences characterised by all of its students coming from the same study field is 10 %, while in about 28 % of the RTGs in the natural and life sciences all of their students come from the same study field. The majority of RTGs in both disciplines comprises students from three or more different study fields. In light of the fact that the ISCED study field classification already represents a rather aggregate classification only distinguishing 22 different fields of study, this is indeed a striking result.

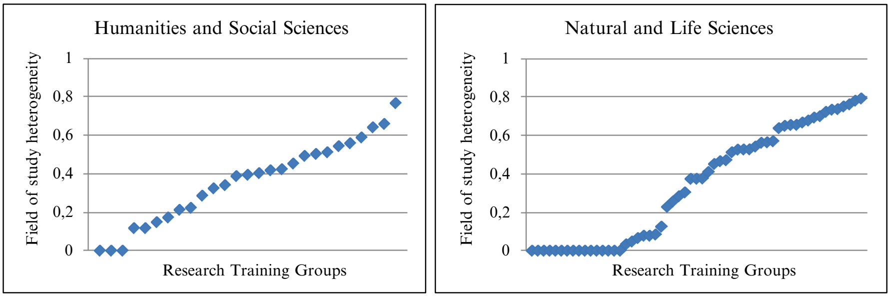

Fig. 2.4 Interdisciplinarity – Blau's index concerning the field of study (Source: Own data)

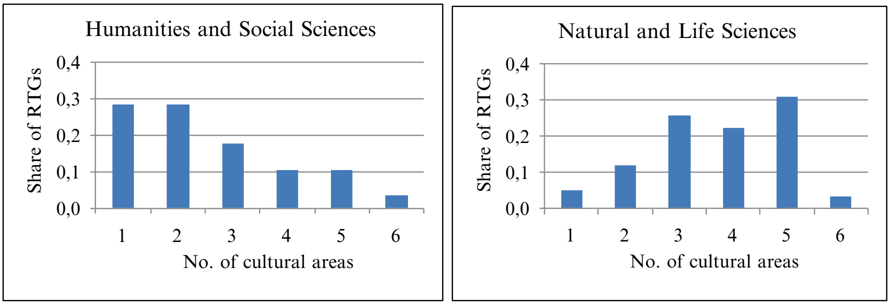

Fig. 2.5 Internationality – no. of cultural areas represented by students in an RTG (Source: Own data)

Figure 2.4 displays the index of heterogeneity according to the field of study of RTG students. As can be seen, no RTG achieves a degree of heterogeneity of 1.0. In both disciplinary fields, the maximum level of heterogeneity concerning the field of study is around 0.8.

Internationality: Our second heterogeneity dimension concerns the question in how far an RTG is characterised by the internationality of its students. Figure 2.5 displays the share of RTGs in the humanities and social sciences (left panel) and in the natural and life sciences (right panel) concerning the number of different cultural areas represented by their doctoral and postdoctoral members. As can be seen, the RTGs from the humanities and social sciences are on average less characterised by internationality than those from the natural and life sciences: In the latter, the majority of the RTGs comprises students from more than three different cultural areas whereas in the former, the majority of RTGs comprises students from at most two different cultural areas.

Figure 2.6 displays Blau's index of heterogeneity according to the cultural area an RTG student comes from. Again, no RTG achieves a degree of heterogeneity of 1.0. In both disciplines, the maximum level of heterogeneity is below 0.8.

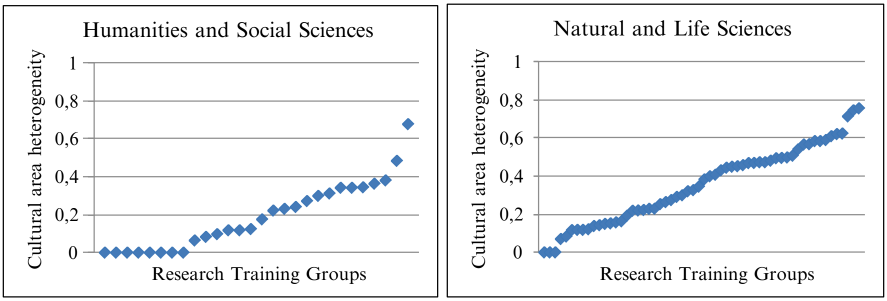

Fig. 2.6 Internationality – Blau's index of heterogeneity concerning cultural areas (Source: Own data)

2.5 Results

In order to analyse the effect of the RTG composition on the RTG performance as measured by the scientific visibility and the doctoral completion rate we employed the seemingly unrelated regressions (SUR). The seemingly unrelated regressions are an extension of the linear regression model and are used for analysing a system of multiple regressions with correlated error terms. As our estimations for scientific visibility and the doctoral completion rate use the same data set, the errors might well be correlated across the equations rendering the use of SUR adequately. In the light of our small data set, we ran separate regressions to test for the potential effects of interdisciplinarity and internationality and also had to abstain from using control variables. However, we estimated two different models in each case: One model tests for a linear relationship between the respective measure of heterogeneity (interdisciplinarity, internationality) and performance. The second model allows for a potentially non-linear relationship between the respective measure of heterogeneity and performance when a quadratic term of the respective heterogeneity measure is added.

2.5.1 RTGs in the Humanities and Social Sciences

Interdisciplinarity: For the humanities and social sciences, heterogeneity concerning the field of study is positively related with the RTG performance as far as scientific visibility, i.e. the publication output per funding year is concerned; there is no indication of the relationship being non-linear. Figure 2.7 visualises the corresponding relationship. It shows that the RTG performance with respect to the doctoral completion rate remains unaffected by the heterogeneity of the study field. In other words, the interdisciplinarity of RTG students has on average positive effects on the RTG performance in the humanities and social sciences.

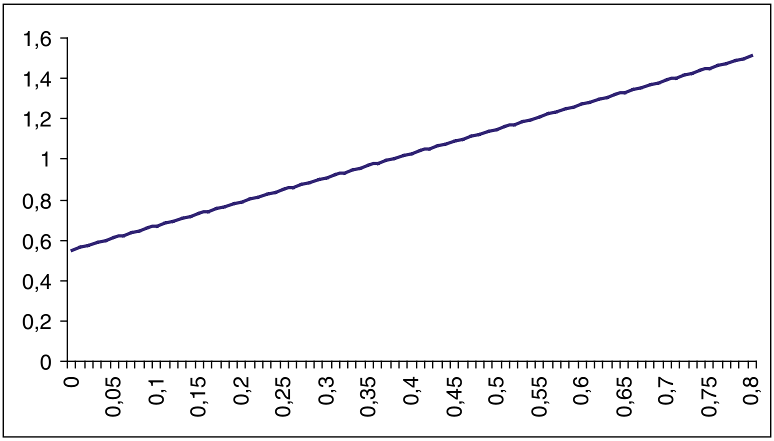

Fig. 2.7 Blau's index concerning the field of study (x-axis) and the no. of publications per funding year (y-axis) in the humanities and social sciences (Source: Own data)

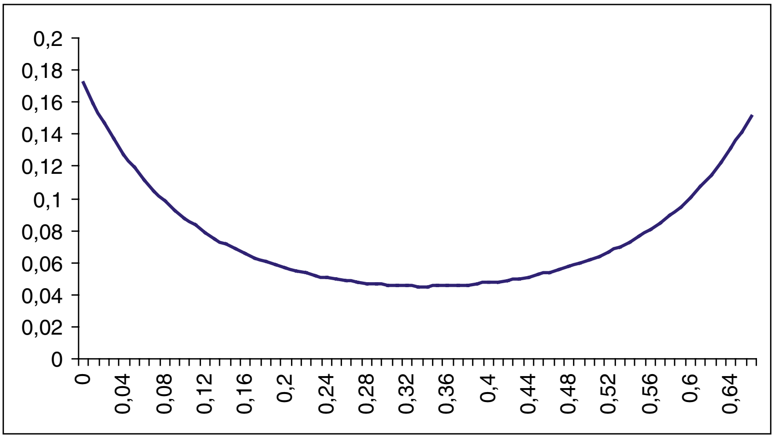

Fig. 2.8 Blau's index concerning the cultural area (x-axis) and the doctoral completion rate (y-axis) in the humanities and social sciences (Source: Own data)

Internationality: Concerning cultural heterogeneity, the picture is quite different: While the scientific visibility remains unaffected by the students' internationality, the doctoral completion rate is affected in the following way: an increasing degree of internationality at first is associated with a lower doctoral completion rate. Once a certain level of cultural heterogeneity is reached, a further increase in heterogeneity raises the doctoral completion rate (see Fig. 2.8). However, even at the highest level of international heterogeneity reached in the data set, the doctoral completion rate is below its value in a completely homogeneous RTG, which comprises only students from one cultural area. In other words, the internationality of RTG students seems to have on average negative effects on the RTG performance in the humanities and social sciences.

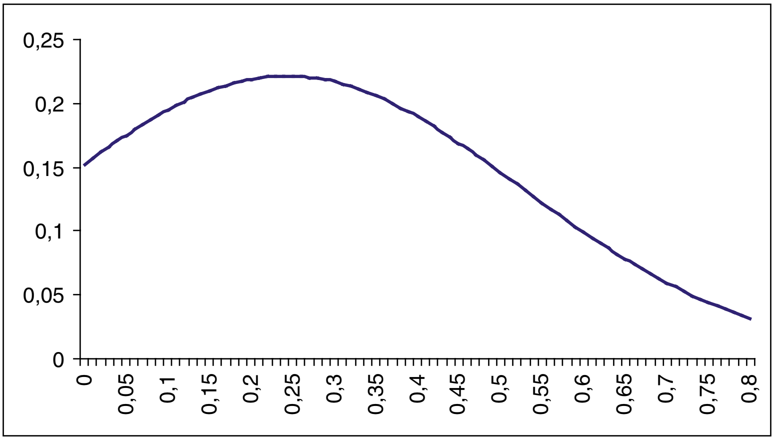

Fig. 2.9 Blau's index concerning the field of study (x-axis) and the doctoral completion rate (y-axis) in the natural and life sciences (Source: Own data)

2.5.2 RTGs in the Natural and Life Sciences

Interdisciplinarity: Using again the seemingly unrelated regressions, we find for the natural and life sciences that the relationship between the study field heterogeneity and the doctoral completion rate is hump-shaped: The regression model including the quadratic term shows that an increase in student interdisciplinarity at very low levels first increases the doctoral completion rate, but then very soon decreases it (Fig. 2.9). The RTG performance with respect to the indicator scientific visibility seemingly remains unaffected by the heterogeneity concerning the field of study.

Internationality: Concerning heterogeneity with respect to student nationality, there is no indication of a linear or non-linear relationship between heterogeneity and performance.

2.6 Conclusion

In this chapter we analysed how one particular governance mechanism affects the performance of research teams. The governance structure we look at is the requirement of interdisciplinarity and internationality of Research Training Groups (RTGs) uttered by the German Research Foundation. We study how the performance of RTGs is affected by the heterogeneity that is induced by an increasing number of study subjects and by an increasing number of cultural areas within a research group. From a theoretical perspective there may be two countervailing effects: according to the resource perspective, team performance should rise with increasing team heterogeneity because the team as a whole has access to a larger set of intellectual resources. However, from a sociopsychological process perspective, team performance might also be endangered by an increase in team heterogeneity because communication between team members may suffer due to different (study field and national) languages, increased conflicts and reduced group cohesion. We expect that the size of both effects depends on the type of research in an RTG and analyse how the overall effect is shaped in the humanities and social sciences as compared to the natural and life sciences.

Using seemingly unrelated regressions, we find for the humanities and social sciences that heterogeneity has significant effects on research performance with study field heterogeneity enhancing scientific visibility, and internationality being inversely hump-shaped related with the doctoral completion rate. In contrast, for the natural and life sciences, we only find a significant effect for the doctoral completion rate exhibiting a hump-shaped relationship with study field heterogeneity.

We conclude that the effectiveness of a particular governance mechanism varies substantially from discipline to discipline. The observed differences may be rooted in profound disciplinary characteristics. Following Becher (1994), Bonarccorsi (2008) and Whitley (2000), knowledge production in the natural sciences – in comparison to the humanities and social sciences – is characterized by a higher functional dependence (i.e. a higher degree to which a scientist needs other human or technical resources as an input for his or her work), by more specialized research topics and standardized operational procedures, by the existence of clear criteria for knowledge verification and by a consensus on the most relevant questions in the research field. To the contrary, research in the humanities and social sciences is characterized by a greater uncertainty, more theoretic diversity, less control on research goals and value-driven results. While research in the natural sciences aims at discovering and explaining, in the humanities and social sciences, understanding and interpretation are in the focus (See Becher and Trowler 2001; Becher 1994; Bonarccorsi 2008; Whitley 2000). That is: While the humanities and social sciences are non-paradigmatic in nature and offer a plurality of well accepted theories and methodologies endowing their students with a more general education, the natural and life sciences represent so-called “paradigmatic sciences” that generally do not allow for different scientific approaches and leave less scope for interpretation. As a consequence, the production processes in the two disciplinary fields are severely different from each other (see e.g. Unger 2010) – a fact that has to be taken into account when designing adequate governance mechanisms.

As theoretically argued and empirically shown, the effects of input oriented governance vary between the scientific fields. What may work well in one disciplinary field may have just the opposite effect in the other. An increasing degree of interdisciplinarity in the humanities and social sciences positively affects the research performance. At the same time, when increasing the degree of interdisciplinarity in the natural and life sciences, positive effects on research performance can only be observed up to a certain point, but not if interdisciplinarity is driven to the extreme. Therefore, it seems reasonable to conclude that in governing research groups, all kinds of external governance should be either precisely engineered to the concerning disciplinary field and its specificities. Alternatively, a menu of options should be offered that allows research teams to choose a structure that is most effective given the specificities of its disciplinary field and the specific research requirements.

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Chapter 3
Bringing Efficiency In?

The Effect of Training Conditions on the Time to the Doctorate in Research Training Groups and Traditional Forms of Doctoral Training in Germany During the 1990s

Andrea Kottmann

3.1 Introduction

Since the mid of the 1980s the traditional German system of doctoral training has constantly been criticised. Mostly, its efficiency was under scrutiny, in particular time to the doctorate, age upon graduation and the employability of doctoral graduates were criticised (Wissenschaftsrat 1995). At the beginning of the 1990s the German Research Foundation (GRF) started to implement Research Training Groups (RTG) as a new form of doctoral training. One rationale beyond this programme was that new forms of doctoral training should increase its efficiency. By implementing more collaborative and more structured forms of research training the RTG should lead to a shorter time to the doctorate (preferably within 3 years), to a lower age upon graduation and to a better employability of graduates.

The design of RTG was mostly oriented to overcome the main critical points of the traditional forms of doctoral training. Though a multitude of different forms of doctoral training existed beginning of the 1990s, several characteristics of the traditional pattern ranging from funding/financing and the legal status of doctoral students at universities to the actual training were criticised as impeding efficiency in doctoral training.[1]

As regards the actual research training a lack of means for training doctoral students as well as the organisation of supervision of the PhD-students as master-apprenticeship model was under critical review. Enders (1999: 31) summarises this critique mostly as targeting the "lack of structure and systematization".

[1] An overview on the special characteristics of the traditional forms of doctoral training in Germany and the differences between traditional forms and more structural forms can be found in Berning and Falk 2006; Hüfner 2004; Enders and Bornmann 2001; Enders and Kottmann 2009.

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The main ambition of the RTG was to overcome this lack of 'structure and systematization' by changing the legal status of doctoral students at universities, strengthening research training and by identifying doctoral training as an autonomous study phase. To achieve these goals the RTG were and still are designed along the following lines (cf. DFG n.d.; Wissenschaftsrat 2002: 23 ff):

- Organisational framework: RTG are constructed as temporary research units at universities and are funded by the DFG. Installing RTG as temporary research units at universities mainly aimed at improving the integration of doctoral students into collaborative research.
- Research programme: Within an RTG doctoral students and professors conjointly work on an overarching, often interdisciplinary research programme related to a shared topic. Within this programme each single dissertation is regarded as an element contributing to this overarching project. The framework also serves as an instrument to direct and bundle the exchange of professors, doctoral students and other scientists, i.e. to serve as a framework for collaboration that prevents doctoral students from working in an isolated setting.
- Study programme: Besides extensive research training RTG also offer a study programme providing training in different topics in line with the research programme. This study programme is designed to support the constant exchange between professors and doctoral students and other scientists visiting/participating in the RTG.
- Innovative supervision: Proposing (interdisciplinary) teams of supervisors aims at dismantling the master-apprentice-relationship and at establishing transparent conditions for supervision.
- Competitive access to doctoral education: RTG are obliged to advertise their fellowships publicly. Doctoral students have to be selected from these applicants and selection procedures should be transparent.

These innovations can mainly be considered to add an organisational framework of doctoral training: instead of working solitary on an independent research project the RTG intended to offer a setting for doctoral students that would allow them to integrate into a collaborative research project, in particular into teamwork and into a (interdisciplinary) network of scientists.

To date some structural characteristics of the RTG have been mimicked and further extended by other new forms of doctoral training (e.g. by different forms of Graduate Schools at universities). Serving as a role model the RTG could be considered to be a success story. Also, the self-evaluation reports of the GRF show that the majority of (former) doctoral students inside the RTG rated the conditions of training very positive; most of them indicated a high level of satisfaction with the RTG (DFG 2000, 2003).

Nonetheless, to date it has not been analysed whether the RTG actually were more efficient than other forms of doctoral training, in particular the performance of RTG has not yet been compared to other forms of doctoral training systematically. Also, it has not been studied yet to what extent the conditions of training differed between the RTG and other forms of doctoral training.

In the following efficiency and the conditions of training in the RTG will be compared to other forms of doctoral training. As regards efficiency we will have a closer look at the time to the doctorate. Regards the conditions of doctoral training the RTG will be compared to other forms of doctoral training for those aspects that the RTG tried to change. Finally, the paper will investigate in the question to what extent different conditions of training and other determinants have contributed to achieve more efficiency in terms of shortening the time to the doctorate.

3.2 Model and Theoretical Approaches

Studies on the time to the doctorate have quite some tradition in the US (e.g. Seagram et al. 1998; Stock and Siegfried 2006; Stricker 1994; Ehrenberg and Mavros 1995; see also overview in Ferrer de Valero 2001). In the vein of institutional research, the time to the doctorate serves as an important indicator to evaluate the effectiveness of doctoral programmes. Accordingly a range of theories and explanatory models using different factors affecting the time to the doctorate have been developed. From this research, two main categories of factors can be distinguished. On the one hand individual characteristics of the doctoral student, for example his/her sociodemographic/sociobiographic background and/or individual educational and academic abilities are identified as important determinants. On the other hand the conditions of doctoral training build a second main category of factors: the organisation and structure of supervision, the quality of supervision, as well as additional activities of the doctoral students during his/her doctoral studies and the integration of the doctoral student into collaborative research are identified as important variables.

In total, this research shows that there is no dominant factor influencing the time to the doctorate. Mostly a very complex combination of different factors from both categories determines the time to the doctorate. In addition, the impact of factors also varies along the lines of the field of study and gender of the doctoral student.

Studying the time to the doctorate therefore needs to take both kinds of factors into account: the individual characteristics as well as conditions of training.

For Germany, the time to the doctorate has not yet been analysed very intensively; despite a strong interest in the topic only a few studies exist (Hauss et al. 2010). Among these studies the work of Bornmann and Enders (2002) has analysed the time to the doctorate most intensively. The authors test five assumptions on the different factors influencing the time to the doctorate (Bornmann and Enders 2002: 62–63). Those also take both kinds of factors into account: the conditions of doctoral training as well as the individual achievements and abilities of doctoral students. Bornmann and Enders (2002; Enders and Bornmann 2001) found strong differences in the time to the doctorate between fields of study. Further, their multivariate analysis made clear that within the different fields of study each factor can have a different impact on the time to the doctorate (2002: 64 ff). Therefore, for the German context a dominant factor influencing the time to the doctorate could not be revealed. Bornmann and Enders findings also make clear that for the German context the field of study and related to that the different field-specific cultures play an important role when looking at the time to the doctorate. Within the different fields of study they found different patterns of transitions to doctoral studies and also different patterns of completing the doctoral thesis.

Our analysis will build on these studies and use both categories of factors. As the field of study plays an important role for both conditions of training as well as time to the doctorate we will in the following compare the RTG to other forms of doctoral training by field of study mainly. In the following we will build an explanatory model that will distinguish between different sets of independent variables contributing to the length of doctoral studies.

3.2.1 Individual Characteristics

For the purposes of our study we define as individual characteristics those personal attributes of doctoral students which are related to their abilities, resources and social origin. In some respect these determinants can be regarded as the input to doctoral education as they mostly refer to the competencies and resources doctoral students bring with them.

In the recent literature on the time to the doctorate individual characteristics refer to a broad set of different attributes of an actor: variables reflecting on the sociodemographic as well as on the sociobiographic background of the doctoral student. Besides these two aspects, our model will consider the past educational performance of the doctoral students before they started their doctoral study.

(a) Sociodemographic Background

The sociodemographic background of a former doctoral student mainly refers to his or her family background. Boudon (1974) identifies class differentials as primary effects on the academic ability of individuals (Breen and Goldthorpe 1997). Parents having a higher education background are able to provide more educational resources to their children than parents without a higher education background. Consequently, it is assumed that children from families with a higher educational background would perform better than children from families with a low educational background. This effect holds in particular true for the school performance of children. For the academic performance of doctoral students this primary effect of social origin has proven to be less important as the group of doctoral students is already highly selective (Enders and Bornmann 2001). Nonetheless we will consider the social origin of former doctoral students to estimate whether the social origin determines the time to the doctorate. In general we assume that doctoral students having parents with a higher educational background will have a shorter time to the doctorate as they can rely on more resources than doctoral students with parents having a low educational background.

(b) Sociobiographic Background

The sociobiographic background reflects those individual characteristics of the former doctoral student which are independent of his or her social origin. With the sociobiographic background we refer to their gender and family status during doctoral studies. Recent research on gender differentials in time to the doctorate has shown that women mostly take longer to complete their doctoral studies than men (cf. Seagram et al. 1998). Two explanations are generally used to explain this gender difference. Firstly, gender differentials in the time to the doctorate are explained by using the 'chilly climate construct' which points to the different experiences of men and women of the university environment and of the supervision relationship. In these studies gender is used to relate to the gendered experiences of the conditions of the doctoral studies assuming that conditions will be experienced differently by women and therefore leads to a longer time to the doctorate. Secondly, gender is often used in conjunction with the family status of the doctoral students during doctoral studies. Different studies reveal that the family status and in particular the number of dependents of the doctoral student have a significant influence on the time to the doctorate (Abedis and Benkin 1987). The higher the number of dependents was the longer also was time to the doctorate. Bornmann and Enders (2002) also found for the German case that starting a family during doctoral studies lengthens the time to the doctorate in particular for women.

For our analysis we assume that gender and family status will have an impact on the time to the doctorate; in general we assume that women will take longer to complete their doctoral studies than men. Further, we assume that having dependents during the time of doctoral studies lengthens the time to the doctorate. For this relationship we also expect gender differentials. We also expect that the sociobiographic background will be less important for doctoral students inside the RTG as the different conditions of training could lead to a better integration of women. We further assume that starting a family during doctoral studies might be easier for students inside the RTG as the training conditions might lead to more opportunities to integrate work and family.

(c) Educational Background

This last set of independent variables representing the individual characteristics refers to the academic performance and ability of the doctoral student. Within the model educational achievements as well as the length of the first study will be considered. Bornmann and Enders (2002) found that the individual abilities of doctoral students have some but no significant influence on the time to the doctorate. In their study students from mathematics who were already high performers in their first study completed their doctoral degree faster.

We assume that former doctoral students who have been high performers in their first study will also perform well in their doctoral studies and therefore have a shorter time to the doctorate. We also assume that the educational performance of doctoral students plays a more important role for the time to the doctorate when comparing students inside and outside the RTG. As doctoral students for the fellowships in the RTG are selected in a competitive procedure we assume that there are more high performers among them than among doctoral students outside the RTG (Bonaccorsi 2015 in this volume). We assume that these higher competencies of doctoral students inside will lead to a shorter time to the doctorate. In addition the conditions of training inside the RTG will support their abilities better and therefore help them to complete their doctoral studies faster.

3.2.2 Conditions of Doctoral Training

With the term conditions of doctoral training we refer to several aspects of doctoral training including for example the organisation of supervision as well as the integration into teaching and research.

Ferrer de Valero's (2001) study on the influence of departmental factors on the study success of doctoral students shows that departments with successful doctoral programmes (=high completion rates and short time to the doctorate) were able to offer some or a combination of the following training conditions to their doctoral students: good financial support, a strong relationship between course work and research skills, a good student-advisor relationship, and peer support. In departments with less successful doctoral programmes (=low completion rate and long time to the doctorate) training conditions were mostly characterised by the following factors: conflict and a lack of collaboration between faculty and graduate students and a negative attitude towards students (cf. Ferrer de Valero 2001: 354 ff). In our analysis some of these aspects will also be considered: The organisation and structure of the supervision of the doctoral candidate, the integration of doctoral students into collaborative research, their integration into academia and finally the doctoral student's research and teaching activities besides working on his or her dissertation.

(a) Organisation and Structure of Supervision
Ferrer de Valero's (2001) study highlighted that an important success factor for doctoral programmes is a good student-advisor relationship (2001: 356). Also other studies support this finding: student's success is mostly dependent on the kind of the supervising relationship (Marsh et al. 2002; Pearson and Brew 2002). While these studies mostly study the quality of the relationship the organisational structure of the supervision is not considered. As one of the main innovations implemented by RTG was to overcome strong dependencies between the doctor father or doctor mother and the doctoral student our model will pay special attention to this aspect. We will distinguish between different organisational forms of supervision and assume that 'new' forms of supervision, i.e. also consider supervision models beyond the traditional master-apprenticeship-relation. We expect that the new forms of supervision will prevail among students inside the RTG and that these will contribute to a shorter time to degree.[2]

[2] To date there has not been much research to what extent the organisational structure of supervision has an impact on the doctoral student's performance. While implementing the RTG the GRF

(b) Integration into Collaborative Research
Besides restructuring the supervision the integration of doctoral students into collaborative research and into an overarching research project was at the heart of the RTG programme. With this instrument the RTG mainly intended to overcome isolated work settings that some doctoral students experienced in traditional training. Some recent studies on the time to the doctorate considered the integration of doctoral students into collaboration and further research. Seagram et al. (1998) found that fast completers among doctoral students are more likely to collaborate with their supervisors. Data on whether the integration of doctoral students in a wider circle of collaboration with other scientist also shortens the time to the doctorate does not exist. In the following we will assume that a stronger integration of doctoral students into collaborative research will have a significant impact and shorten the time to the doctorate. For the integration into collaborative research we will consider research liaisons with the supervisor(s) as well as with other scientists and doctoral students. Again, we expect that doctoral students inside the RTG were more often integrated into collaborative research and therefore completing their doctoral studies faster.

(c) Integration into Academia
Integration into academia points to the participation of doctoral students into the wider academic community while publishing and actively participating in scientific conferences. Research on the time to the doctorate has not yet considered this aspect. We assume that one can expect both a shortening as well as a lengthening effect on the time to the doctorate. A strong integration into academia can shorten the time to the doctorate as participation in the wider academic community via publications or active conference participation forces the doctoral students to publish research results faster. On the other hand integration into academia can also be considered as a retarding factor when doctoral students spent too much time on preparation for conferences or do not focus their participation in the wider academic community. Comparing training conditions inside the RTG to conditions outside the RTG we expect that the RTG will on the one hand offer more opportunities to doctoral students to publish and participate in conferences. We also assume that these activities will be strongly related to the PhD research of the doctoral students inside the RTG and therefore help him or her to complete their doctoral studies faster.

(d) Research and Teaching Activities besides Working on Dissertation
Finally, we will consider research and teaching activities of the doctoral students during his or her doctoral studies. Within the traditional model of doctoral

assumed that (interdisciplinary) teams of supervisors would help to overcome the traditional dependence relationship between doctoral student and his/her doctor father or mother. Pferdmenges, Pull and Backes-Gellner's study on the composition and performance of the research training groups (2015, in this volume) made clear that in RTG group heterogeneity does not *per se* lead to a better performance of the group, only under certain conditions heterogeneity also leads to a higher research performance. Our assumption therefore should be understood as tentative.

training participating in teaching and further research were the key instruments in training doctoral students. Bornmann and Enders (2002) assume that these activities besides working on the dissertation would lengthen the time to the doctorate because these would distract doctoral students from their own PhD research. Bornmann and Enders' results did not fully support this assumption: on the one hand they find that additional activities impede the completion of the doctoral degree. On the other hand they also show that the integration of the doctoral students into collaborative research which comes along with these additional activities has a shortening effect on the time to the doctorate. In the following we will assume that teaching and research activities besides working on the dissertation will lengthen the time to the doctorate as these activities will force doctoral students to discontinue their PhD research more often. As the RTG aimed to reduce the involvement of doctoral student into activities which are not directly related to their PhD we expect that students inside the RTG were less often involved in these further activities and that they therefore complete their doctoral studies faster.

3.3 The Study: New Forms of Training: Different Careers

Our analysis is based on a large scale survey among doctoral degree holders graduating in Germany during the 1990s. The survey was undertaken in 2005 and included former doctoral students working on their dissertation between 1990 and 2000.[3] The sample included former members of the RTG as well as PhD-holders graduating in a 'traditional' setting of doctoral training.

For the RTG-group all former doctoral students participating in one of the RTG of the German Research Foundation in the period between 1990 and 2000, in total 8,450 persons, have been included in the sample. To build the subsample of former doctoral students who have been trained in a traditional setting we applied a structured random sampling based on the year of graduation, sex and the academic discipline of the doctorate. These former doctoral students were drawn from the catalogue of the National Library in Frankfurt/M. In total about 4,320 PhD-holders who graduated in 1994 or 1995 or who graduated in 1999 or 2000 have been included in this sample. Both groups of former doctoral students have been surveyed with the same questionnaire asking for the processes and outcomes of doctoral training and later careers. About 4,676 persons responded to the survey; 2,618 former RTG-members and about 2,058 traditional doctoral students.

For the following analysis two new subsamples had to be drawn from the gross sample. As the gross sample included doctoral students form a multitude of different

[3] The study was funded by the DFG and led by Jürgen Enders.

Table 3.1 Subsamples

	Inside RTG		Outside RTG	
	n	%	n	%
Arts and humanities/social sciences	166	32	154	30
Life sciences	61	12	63	12
Sciences	194	37	231	45
Engineering	100	19	70	14
Total	521	100	518	100

Data source: PhD-Survey 2005, own calculations

forms of doctoral training we had to identify two subgroups in the sample to achieve a high degree of comparability.[4]

From the former RTG-members persons who successfully finished their dissertation between 1996 and 2000, who have been a fully funded member of a RTG with for at least 24 months have been included in the subsample which will be in following referred to as students 'inside RTG'.

From the traditional doctoral students those respondents graduating in 1999 or 2000 and whose main funding source during doctoral studies has been a job at university have been assigned to the subsample 'outside RTG'. Table 3.1 shows the composition of these two comparison groups as regards disciplinary fields.

3.4 Results I: Time to the Doctorate

Within our study, time to the doctorate is measured as the time difference between the date when the doctoral student started to work on his or her PhD and the date when he or she defended her thesis successfully in the final oral examination.[5]

The median time to the doctorate for all doctoral students from the subsample inside RTG was about 44 months. For all former doctoral students outside RTG the median time was about 49 months. Although this difference is small it is significant. Comparing categorised data on the time to the doctorate confirms that in general former doctoral students inside RTG completed their PhD earlier than doctoral students outside RTG: after 48 months about 63 % of them had already graduated while only 49 % of the doctoral students outside the RTG had.

As Bornmann and Enders (2002) already showed for the PhD-holders graduating in the 1980s time to the doctorate varies significantly among the different disciplinary fields (cf. Table 3.2).

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[4] More details on the sample can be found in Enders and Kottmann (2009).

[5] Bornmann and Enders (2002: 55) distinguish between the time to the doctorate, which is the time difference between the end of the first study and the successful graduation from doctoral study and the time span of actually completing and successfully defending the PhD.

Table 3.2 (Median) time to the doctorate, in %, by disciplinary field

	Arts and humanities/ social sciences	Life sciences	Natural sciences	Engineering	Total
Inside RTG					
Median time to the doctorate in months	47	45	41	45	44
Time to the doctorate – categorised					
Up to 24 months	0	0	1	0	0
Up to 36 months	16	20	28	10	20
Up to 48 months	36	39	49	49	44
Up to 60 months	25	22	14	19	20
More than 60 months	23	19	8	21	17
Outside RTG					
Median time to the doctorate in months	54	49	42	60	49
Time to the doctorate – categorised					
Up to 24 months	2	2	1	1	1
Up to 36 months	11	10	22	9	15
Up to 48 months	21	37	44	21	33
Up to 60 months	32	31	22	23	26
More than 60 months	34	21	11	46	24

Data source: CHEPS-PhD-Survey 2005, own calculations

Similar to Bornmann and Enders (2002) we find that PhD-holders from the natural sciences in both subsamples completed their doctoral degree fastest. Former doctoral students inside RTG needed about 41 months to complete their doctoral degree and four out of five students had already graduated after 48 months. Students outside RTG needed about 42 months to complete their doctoral degree, from them only two thirds had graduated after 48 months.

For doctoral students from engineering a very diverse picture can be revealed. While students from engineering took longest to complete their PhD among the students outside the RTG, students inside the RTG were completing in average time. Students outside the RTG took about 15 months longer than students inside the RTG to complete their PhD.

Doctoral degree holders from arts and humanities/social sciences took in both groups longest to finish their doctoral studies. Further, the difference between the median times to the doctorate is here rather small.

The results show that former doctoral students inside RTG completed their doctoral degree faster than students outside the RTG. But it becomes also clear that the RTG did not really achieve the big gain in efficiency as regards the time to the doctorate. The majority of students inside the RTG needed more than 3 years to graduate.

Looking on the time to the doctorate in more detail shows that there is a difference between students inside and outside the RTG regards discontinuations during their doctoral studies (cf. Table 3.3). From the former doctoral students outside RTG every fifth had to discontinue his or her doctoral studies for a period of 17 months

Table 3.3 Discontinuations of doctoral studies

	Arts and humanities/ social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Experience of at least one discontinuation while working on PhD (in %)	23	37	20	13	7	11	11	20	14	20
Average duration of discontinuation (in months)	11	20	9	14	11	11	11	21	11	17

Data source: PhD-Survey 2005, own calculations on average. From the former students inside the RTG a lower number has discontinued their doctoral studies (14 %) for a shorter period of 11 months on average. Again, this aspect differs strongly among the different the disciplinary fields. Students from arts and humanities/social sciences were most likely to discontinue their doctoral studies for a longer period in both groups. But we find that a much higher number of former students outside RTG had to interrupt their studies for a longer period compared to students inside the RTG. While being on a much lower level this finding also applies to students from engineering. For the natural sciences the data shows only slight differences between the two groups.

Comparing the two groups as regards discontinuations of their PhD work further differences can be revealed. Former doctoral students outside RTG mostly discontinued their doctoral studies because of additional workloads besides their PhD research or because they experienced problems with their supervisor(s). Students inside RTG mostly experienced discontinuations when they were starting a new job (mostly after the end of the fellowship) or starting a family. Problems with conditions of training or with the supervisor were no important reasons to discontinue studies for this latter group. Thus, against our first assumptions these results show that the conditions inside the RTG did not provide better conditions to easily integrate family and PhD-research.

The results on the discontinuations in PhD research can be interpreted from two angles: on the one hand results show that the RTG provided a more stable framework to doctoral students inside the RTG. They experienced less discontinuation and have not been distracted from their PhD research as often as the former doctoral students outside the RTG. The RTG provided opportunities that allowed doctoral students to fully concentrate on their PhD research. On the other hand, given the opportunity to be able to fully concentrate on the PhD research, it is quite disappointing that students inside the RTG did not really need less time to complete their PhD. Excluding periods of discontinuations from the calculation of the time to the doctorate reveals that there is hardly any difference between the former students inside and outside the RTG (cf. Table 3.4).

Given these little differences in the net time to the doctorate one could assume that the main effect of the RTG was to release doctoral students from additional work in research and teaching while not changing the conditions of doctoral training itself. In the following we will analyse in more detail how training conditions contributed to a lengthening of doctoral studies.

3.5 Result II: Individual Characteristics of Doctoral Students

Looking at the sociodemographic, sociobiographic and educational background reveals that former doctoral students inside and outside the RTG did not differ very much. Both groups were as regards their sociodemographic background already highly selective. In total, 53 % of the students inside the RTG and 49 % of the

Table 3.4 Time to the doctorate with/without periods of discontinuation

	Arts and humanities/ social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Time to the doctorate in months including periods of discontinuation	47	54	45	49	41	42	45	60	44	49
Time to the doctorate in months excluding periods of discontinuations	46	48	44	49	40	42	44	57	43	46
n	*159*	*149*	*59*	*62*	*189*	*224*	*98*	*70*	*505*	*505*

Data source: CHEPS PhD-Survey 2005, own calculations

students outside the RTG have a father with a higher education degree. 12 % of the students inside the RTG had a father who with a PhD, this also applied to 10 % of the students outside the RTG.

Also, differences in the sociobiographic background of doctoral students inside and outside the RTG were low. In both groups every third student was female; so the RTG did not provide more chances to women to pursue a doctoral degree than other forms of training. In both groups about 80 % were having a partner during his or her doctoral studies. Finally, nearly 20 % in both groups had one or more children/dependents during their doctoral studies.

Comparing the educational background demonstrates that students from both groups shows that students in both groups were already high performers in their first study. Former doctoral students inside the RTG did not have better final grades for their first study; also they have not completed their first study faster than students outside the RTG (cf. Table 3.5). Thus, it seems that both forms of doctoral training have attracted high performers, and that the competitive model of the RTG did not lead to a "better input" in terms of more high performing doctoral students.

3.6 Results III: Differences in the Conditions of Doctoral Training

The main rationale underlying the programme of the RTG is to implement an organisational/structural framework to doctoral training. This framework is designed to integrate doctoral students better into collaborative research, also into wider academia and finally to improve the quality of supervision.

In the following we will analyse to what extent the conditions were different in both forms of doctoral training. For this question we are particular interested in how the differences between the both groups for the disciplinary fields looked like and if the different disciplinary cultures of doctoral training have been affected by the implementation of the RTG.

(a) Organisation and Structure of Supervision

Comparing doctoral students inside and outside RTG we find that in both forms of doctoral training most students were still supervised by one professor only. In total, we do not find a broad institutionalisation of supervision teams inside the RTG. This aspect appears differently for the arts and humanities/social sciences and the doctoral students from engineering. In these disciplinary fields students inside the RTG were supervised by teams more often than students outside the RTG. In particular, students from arts and humanities/social sciences were supervised by teams much more often than students outside the RTG.

For those students who have been supervised by teams we find that inside the RTG mostly students from arts and humanities/social sciences and from engineering had more often an interdisciplinary supervision team. Students

Table 3.5 Educational background

	Arts and humanities/social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Final grade first study[a]										
Mean	1.3	1.3	1.1	1.3	1.2	1.3	1.2	1.4	1.2	1.3
Median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
n	*140*	*123*	*48*	*53*	*165*	*201*	*83*	*57*	*436*	*434*
Length of first study in months										
Mean	67.6	67.9	68.8	68.6	67.2	65.7	65.3	65.3	67.1	66.6
Median	68.5	68.0	68.0	70.0	66.0	66.0	66.0	60.0	68.0	67.0
n	*136*	*129*	*51*	*49*	*180*	*210*	*88*	*62*	*455*	*450*

Data source: CHEPS PhD-Survey 2005, own calculations
[a]Final grades on a scale from 1 = excellent to 5 = not sufficient

from life sciences and natural sciences inside as well as outside the RTG both experienced interdisciplinary teams of supervisor to the same extent.

The cooperation among supervisors also seems to be determined by disciplinary fields. In the life sciences and the natural sciences as well as in engineering cooperation among the supervisors was very common while in arts and humanities/social sciences only half of the supervisors have cooperated. Comparing students inside and outside the RTG shows that when supervising teams were in place cooperation among the supervisors was not determined by the form of doctoral training but mostly by the disciplinary field (cf. Table 3.6).

The frequency as well as the quality of supervision was evaluated very positively by both groups of doctoral students. Again, results do not show any difference between students inside and outside the RTG (cf. Table 3.11 in Annex). Students from natural sciences showed the highest level of satisfaction with the frequency and quality of supervision.

Looking at the evaluations of the support of supervisors reveals bigger differences between the disciplinary fields and also among students inside and outside the RTG (cf. Table 3.11 in Annex). Students from natural sciences evaluated the support of supervisors mostly positive; here also differences between the different forms of training were only small. Students from arts and humanities/social sciences and from engineering evaluated the support of their supervisors less positive. Comparing students inside and outside the RTG for this disciplinary field shows that students inside the RTG evaluated the support of their supervisors better than students outside the RTG. For students from engineering a reverse picture can be depicted. Here students outside the RTG were more satisfied with their supervisor's support than students inside the RTG.

To conclude, within the RTG the organisational structure of supervision has only been innovated to a slight degree. This can only be found for some disciplinary fields; nonetheless the traditional organisation of supervision specific to the different disciplines prevailed also inside the RTG, particular in the life sciences and the natural sciences.

(b) Integration into Collaborative Research

One of the major targets of the RTG is to better integrate the doctoral students into collaborative research. This approach mainly aimed at avoiding dependencies of the doctoral student from his or her supervisor. Also, a strong integration of the doctoral student into a collaborative research should help to provide a better research training.

The survey results show that in total former doctoral students inside and outside the RTG did not experience integration into collaborative research to a very high extent. In total, both groups of doctoral students did not evaluate their integration into different aspects of doctoral research very differently.

Within the disciplinary fields we only found slight differences between students inside and outside the RTG, expect for the arts and humanities/social sciences. On the one hand doctoral students from this disciplinary field reported the lowest extent of integration into collaborative research. On the other hand

Table 3.6 Organisation of supervision

	Arts and humanities/ social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Number of supervisors										
One supervisor	36	67	57	57	61	66	60	73	53	66
Two supervisors	46	27	37	36	32	30	31	23	37	29
More than two supervisors	18	6	7	7	6	4	9	4	10	5
n = 100 %	*157*	*150*	*60*	*61*	*189*	*228*	*100*	*70*	*506*	*509*
Interdisciplinary team										
Yes	50	42	35	35	33	22	60	21	45	29
No	50	58	65	65	67	78	40	79	55	71
n = 100 %	*98*	*48*	*26*	*26*	*70*	*78*	*40*	*19*	*234*	*171*
Did the supervisors cooperate										
Yes	54	51	88	71	82	85	77	63	70	71
No	46	49	13	29	18	15	23	37	30	29
n = 100 %	*95*	*49*	*24*	*24*	*72*	*78*	*39*	*19*	*230*	*170*

Data Source: CHEPS-PhD Survey 2005, own calculations comparing students inside and outside the RTG reveals that the students inside the RTG experienced integration into collaborative research to a higher extent than students outside the RTG (Table 3.7).

(c) Integration into Academia
The participation in academe by exchanging research results via talks and publications can be regarded as a factor that contributes to the integration of the doctoral student into wider academic community. One could expect that the special organisation of the RTG would allow doctoral students to achieve a higher degree of integration into the wider academic community as the RTG provide more opportunities to publish and to visit scientific conferences.

Across the board survey results show that former doctoral students inside the RTG were to a slight degree more likely to visit conferences than doctoral students outside the RTG. On the other hand they published less often in addition to their doctoral thesis than students outside the RTG. Further results on the active participation in conferences and additional publications show that students outside the RTG have also been more productive than students inside the RTG (cf. Table 3.8).

This finding applies in particular to the students from arts and humanities/social sciences outside the RTG as well as to students from natural sciences outside the RTG. Both were much more active in publishing book chapters and journal articles than students inside the RTG.

(d) Research and Teaching Activities besides PhD Research
The results on the time to the doctorate and discontinuations experienced during doctoral studies have already shown that doctoral students outside RTG spend more time on activities besides their PhD research than students inside RTG. Looking at these activities in more detail we find that also quite a number of the doctoral students inside the RTG performed additional activities. Nearly half of them participated in further research projects or were actively teaching and counseling students. More than 60 % were also working for the different organisational tasks related to the RTG (cf. Table 3.9).

Nonetheless, performing additional tasks beside the PhD research discerns former doctoral students inside the RTG from students outside the RTG. This becomes evident when comparing the two groups within the different disciplinary fields. While the majority of doctoral students in arts and humanities/social sciences outside the RTG were teaching and participating in research projects only a low number of the students inside did. This difference can also be found for the doctoral students from the natural sciences. Among students from the life sciences the difference between the two groups was only low.

Summarising the findings on the conditions of doctoral training we can state that the RTG did not change these. Only in some disciplinary fields and only for a few aspects the RTG have implemented different training conditions. Mostly doctoral students from arts and humanities/social sciences inside the RTG experienced different training conditions, in particular a stronger integration into collaborative research.

Table 3.7 Integration into collaborative research, mean and median[a]

	Arts and humanities/ social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Integration into collaborative research										
…into cooperative research project										
Mean	3.7	4.3	2.8	3.2	2.7	2.8	3.0	2.9	3.1	3.3
Median	3.0	5.0	2.0	3.0	2.0	2.0	3.0	2.0	3.0	3.0
…into longstanding research interests of supervisor										
Mean	3.2	3.5	1.9	2.1	2.0	1.9	2.6	2.6	2.5	2.5
Median	3.0	3.0	1.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0
…into collaboration with other PhD students										
Mean	3.8	4.6	3.2	3.4	3.0	2.8	2.9	3.1	3.2	3.4
Median	4.0	6.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0
…exchanging with other experienced scientists										
Mean	2.1	2.9	1.9	2.4	2.1	2.2	2.3	2.5	2.1	2.5
Median	2.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
n	*166*	*154*	*61*	*63*	*194*	*231*	*100*	*70*	*521*	*518*

Data source: CHEPS PhD-survey 2005

[a]On a scale from 1 = to a very high extent to 5 = not at all

Table 3.8 Conference participations and further publications during doctoral studies

	Arts and humanities/ social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Conferences										
Participation in conferences, in %	93	83	100	100	98	94	96	99	97	92
Number of conferences										
Mean	5.7	6.9	4.7	4.4	5.2	5.7	5.9	8.2	5.4	6.2
Median	5.0	5.0	3.0	4.0	5.0	5.0	5.0	6.0	5.0	5.0
n	*140*	*119*	*60*	*63*	*183*	*215*	*90*	*62*	*473*	*459*
Actively participated in … conferences										
Mean	3.8	4.7	3.7	3.4	5.8	4.5	4.8	6.6	4.8	4.7
Median	3.0	3.0	3.0	3.0	3.0	3.0	4.0	5.0	3.0	4.0
n	*113*	*94*	*45*	*52*	*154*	*189*	*81*	*58*	*393*	*393*
Publications										
Additional publications during doctoral studies, in %	71	81	87	87	80	87	93	93	80	86
Number of book chapters										
Mean	3.5	3.2	1.9	2.0	2.3	1.7	1.6	1.7	2.9	2.7
Median	2.0	2.0	1.0	1.0	2.0	1.0	1.0	1.5	2.0	2.0
n	*65*	*86*	*7*	*7*	*15*	*29*	*17*	*14*	*104*	*136*
Number of journal articles										
Mean	2.3	4.0	3.5	3.1	3.2	5.1	2.9	4.0	2.9	4.4
Median	2.0	2.5	3.0	2.0	3.0	3.0	2.0	3.0	2.0	3.0
n	*77*	*94*	*46*	*53*	*133*	*188*	*59*	*47*	*315*	*382*
Number of research reports										
Mean	2.0	2.8	2.3	2.2	2.5	2.9	2.7	3.7	2.5	3.0
Median	2.0	2.0	3.0	2.0	2.0	2.0	2.0	3.0	2.0	2.0
n	*20*	*30*	*3*	*14*	*34*	*48*	*27*	*30*	*84*	*122*

Data source: CHEPS PhD-Survey 2005, own calculations

Table 3.9 Research and teaching activities besides PhD research

	Arts and humanities/ social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Participating in research projects	31	60	59	63	43	59	47	79	42	63
Teaching	37	81	62	62	48	70	49	84	46	74
Counseling/supervision of students	24	80	57	68	56	65	58	86	46	73
Scientific services (library, etc.)	9	36	20	24	23	30	20	43	18	33
Organisation of events	42	60	36	27	33	37	41	60	38	46
Cooperation with other PhD students	31	19	23	8	13	10	20	11	21	12
Responsibilities in the RTG	64	8	67	3	58	5	71	3	63	5
Other	17	26	10	11	7	10	8	20	11	16
n = 100 %	*162*	*154*	*61*	*63*	*190*	*231*	*98*	*70*	*511*	*518*

Data Source: CHEPS PhD-Survey 2005, own calculations

Despite these little differences, two main differences in the training conditions between students inside and outside the RTG may be highlighted:

- Inside the RTG doctoral students were less often performing additional activities in teaching and research besides working on their PhD. This condition gave them more chance to continuously concentrate on their dissertation.
- Further, in particular doctoral students from arts and humanities/social sciences inside the RTG faced a new framework for doctoral training. They had more often a team of supervisors and were more often integrated into collaborative research than students outside the RTG. For students inside the RTG from the other disciplinary fields the doctoral training was not really different. In particular differences among the students from natural sciences were only small as the organisational form of the RTG mostly mimicked training conditions from this disciplinary field.

Nonetheless, given the only slight differences in the outcomes we will in the following investigate to what extent the different factors determined the time to the doctorate in both forms of doctoral training.

3.7 Determinants of the Time to the Doctorate

In this section we will investigate to what extent the different factors will influence the time to the doctorate. The foregoing results already made clear that the differences between students inside and outside the RTG were only small. Only for students from arts and humanities/social sciences inside the RTG different training conditions have been established. In the following we will analyse if – even though differences between both forms of training were only low – conditions of training mattered in a different way for the time to the doctorate inside or outside the RTG and within the different disciplinary fields. To receive more insight into the impact of the training conditions we will in the model also contrast training conditions to the individual characteristics (Table 3.10).

Results of the GLM[6] show that some individual characteristics and conditions of doctoral training have significant influences on the time to the doctorate. From the individual characteristics the educational background of the doctoral students are very important factors in all disciplinary fields. From the conditions and forms of doctoral training we cannot derive a similar picture; for each factor a very different impact within the different disciplinary fields can be distinguished.

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[6] The results in the table show the impact of the factors on the time to the doctorate. Positive values indicate that the factor is lengthening the time to the doctorate; negative values indicate the reverse effect. The final grade of the first study reflects the German school grading system; the scale is from 1 = very good to 4 = sufficient. The items for integration into collaborative research were measured on a Likert scale ranging from 1 = to a very low extent to 5 = to a very high extent. Both factors, final grade and integration into collaborative research, were integrated as continuous data into the GLM.

Table 3.10 Determinants of the time to the doctorate, generalised linear model, main effects

	Arts and humanities/ social sciences		Life sciences		Natural sciences		Engineering	
	Inside RTG (n=96)	Outside RTG (n=94)	Inside RTG (n=39)	Outside RTG (n=41)	Inside RTG (n=132)	Outside RTG (n=171)	Inside RTG (n=68)	Outside RTG (n=48)
Individual characteristics								
Gender								
Female	4.616*	−2.890	7.754*	5.075	1.572	−1.329	4.940*	−1.752
Father has higher education degree								
Yes	−0.742	−0.630	−0.253	9.203*	−2.231	1.902	2.746	−7.295*
Having a partner during doctoral studies								
Yes	−2.564	−7.310*	−10.301*	−4.172	−5.585**	1.469	−6.269*	−1.784
Dependents during doctoral studies	6.791**	0.671	16.499**	5.754*	3.958*	−0.517	−2.471	0.978
First study								
Length	0.313**	0.201**	0.235*	0.248*	0.119*	−0.103*	0.229*	0.686**
Final grade	−1.250	−7.920**	−6.681	0.636	−1.306	6.147**	7.342*	10.143**
Conditions of doctoral training								
Organisation of supervision								
Single supervisor	2.912	4.271	14.481*	−10.164*	3.271	1.683	−6.501*	−8.337
Intradisciplinary team of supervisors	−0.219	2.457	17.421*	−9.804*	−2.432	5.970*	−15.528**	−13.748*
Interdisciplinary team of supervisors	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

(continued)

Table 3.10 (continued)

Additional publications during doctoral studies								
Yes	–1.459	3.560	–0.772	7.622*	–4.634*	1.126	10.263	–21.638*
Actively participating in conferences during doctoral studies								
Yes	–11.218**	2.856	0.000	0.000	–19.642*	0.597	–5.915	52.571**
Participating in further research projects during doctoral studies								
Yes	5.099*	1.137	0.926	8.540*	3.645*	3.635*	5.443*	12.212*
Teaching during doctoral studies								
Yes	4.218*	6.780*	–3.569	–4.058	0.108	0.338	–2.265	12.878*
Integration into collaborative research								
Cooperative research project	0.617	–0.892	1.517	1.339	–0.409	–0.547	0.574	–0.864
Interests of supervisor	1.737**	1.323*	–0.406	0.954	1.084*	0.581	1.783*	1.860
Work with other PhD students	0.105	0.742	–1.924	–1.201	–1.867*	1.300*	–1.285	–1.001
With other experienced scientists	–0.364	3.011**	2.767*	1.193	0.829	–1.436*	0.482	0.479

*$p \leq 0.05$; **$p = 0.000$
Data Source: CHEPS PhD-Survey 2005, own calculations

(a) *Results for the arts and humanities/social sciences*
Comparing students inside and outside RTG in the arts and humanities/social sciences shows that factors have a very different influence within these groups. Most surprisingly results depict that gender and a higher number of dependents have lengthened the time to the doctorate significantly for the former doctoral students inside the RTG. Both determinants did not play a role for the students outside the RTG. From these students females took less time to complete their doctoral degree. On the other hand students outside the RTG benefitted from having a partner during their doctoral studies. The educational background mattered as well: While a higher length of the first study only was increasing the time to doctorate only to a slight extent the final grade of the first study can be considered as a strong and significant factor shortening the time to the doctorate for the students outside the RTG. The conditions of doctoral training had a different impact inside and outside the RTG. While actively participating in conferences was shortening the time to the doctorate for students inside the RTG significantly, it was lengthening the time to the doctorate for the students outside the RTG. Teaching and participating in further research projects was an impeding completion in both groups. Conditions of doctoral training specific to the RTG in particular the organisation of supervision did not matter for the time to the doctorate in a significant way, but results show that having only one supervisor has lengthened the time to the doctorate for the students outside the RTG. Students inside the RTG benefitted from having an intradisciplinary team of supervisors. The results for the integration into collaborative research show that the longstanding interest of the supervisor had a significant impact on the time to the doctorate in both groups: being less integrated in his or her interests was lengthening the time to the doctorate in both groups. Also, for students outside the RTG being less integrated in exchange/cooperation with other experienced scientist was lengthening the time to the doctorate.

(b) *Results for the life sciences*
Results for the students inside and outside the RTG in the life sciences reveal that the individual characteristics have a similar influence on the time to the doctorate like in the arts and humanities/social sciences. Again, it becomes clear that being female and the number of dependents have a significant and very strong effect on lengthening the time to the doctorate for students inside the RTG. Additional activities besides working on the dissertation did not much influence the time to the doctorate; only for students outside the RTG who were also involved in participating in further research projects we find that this activity was lengthening their time to the doctorate significantly. For both groups also the organisation of supervision mattered: Inside the RTG single supervisors or intradisciplinary teams were impeding the completion of the doctorate compared to interdisciplinary teams. Outside the RTG we find a contrary effect: here students with single supervisors or intradisciplinary teams were completing faster. Being integrated into collaborative research did not play a role for both groups of students, only for former doctoral students inside the RTG it

becomes clear that being less integrated into exchange with other experienced scientists was lengthening the time to the doctorate.

(c) *Results for the natural sciences*
For the students from the natural sciences it becomes clear that individual characteristics were less important for the time to the doctorate than for students from the other disciplinary fields. In particular we find that being female did not have a significant impact. For students inside the RTG the number of dependents was affecting the length of doctoral studies significantly but also less dramatically than for students from the other disciplinary fields. While the descriptive results on the conditions of doctoral training discerns that these were mostly similar for students inside and outside the RTG the GLM shows that these conditions are influencing the time to the doctorate in a different way. Students inside the RTG benefitted from the additional publications, active participation in conferences and being less involved in the collaboration with other PhD students. These factors shortened their time to the doctorate in a significant way. Participation in further research projects as well as being less integrated into the research interests of their supervisors were factors that were lengthening the time to the doctorate. For students outside the RTG only participation in further research projects was shortening the time to the doctorate. Here having an intradisciplinary team of supervisors, participating in further research projects or being less integrated into an exchange with other PhD Students were impeding the completion of the doctorate.

(d) *Results for engineering*
Comparing former doctoral students inside and outside the RTG from engineering shows that regards the individual factors that being female had a lengthening effect on the time to the doctorate. The educational background of the doctoral students was also important; in particular a good final grade of the first study was shortening the time to the doctorate to a high extent. The organisational structure of supervision had a significant impact for doctoral students inside the RTG. Students who had one supervisor only or an intradisciplinary team of supervisors completed the doctorate faster than students having an interdisciplinary team of supervisors. Some other conditions of doctoral training had different effects in both groups. While teaching and active participation in conferences were shortening the time to the doctorate for the students inside the RTG, they were impeding completion for students outside the RTG. These students on the other hand were completing faster when they also had additional publications during their doctoral studies.

Finally, comparing the disciplinary fields for the effects of the specific characteristics of the RTG we find that these had a very different impact on the time to the doctorate within these different fields. In particular innovative forms of supervision did not shorten the time to the doctorate. Moreover, having an interdisciplinary team of supervisors was even lengthening the time to the doctorate inside the RTG. Also, the effects of integrating the doctoral students into collaborative research were less strong than expected and for some disciplinary fields even counterproductive. Most striking is the strong effect of gender on the time to the doctorate which was found for students inside the RTG from three out of the four disciplinary fields. Being female and/or having a higher number of dependents during doctoral studies were factors that lengthened the time to the doctorate to a very high extent. Both factors did not have a significant impact on the time to the doctorate for students outside the RTG.

3.8 Conclusions

Returning to the main question of this paper we can state that the training conditions in the RTG did not contribute to a shortening of the time to the doctorate compared to the traditional doctoral training. The descriptive data shows that the conditions of training differed only slightly in some disciplinary fields while in other disciplinary fields, in particular in the natural sciences, training conditions were nearly similar. Also, the data on the time to the doctorate shows that students inside the RTG did not complete their doctoral studies faster than students outside the RTG. The comparison of the net time to the doctorate even shows that there is hardly any difference between the two groups. But the results also depict that students outside the RTG had to discontinue their doctoral studies more often and for a longer period than students inside the RTG.

Despite these only slight differences between both groups our GLM analysis revealed that the factors investigated above have a very different impact on the time to the doctorate in the two groups. Like in recent research on the time to the doctorate we can state that no dominant factor can be distinguished as lengthening or shortening the time to the doctorate. Rather, we find very different sets of factors for each of the disciplinary fields and also for the both groups.

Surprisingly, the special characteristics of the RTG, which have been introduced as innovation and sometimes even as an improvement of doctoral training when implementing the RTG were not very important compared to other factors. In some respects these factors were even lengthening the time to the doctorate. Also, the competitive selection of PhD students did not lead to 'better' results in terms of a shorter time to the doctorate.

Given these only slight differences in the conditions of doctoral training we therefore conclude that the RTG in the 1990s did not establish a complete new form of doctoral training. In practice RTG mostly took up central characteristics of traditional training and added new RTG elements to it. Mostly these newly added training elements were impeding the completion of the doctorate as they can be understood as add-ons for the majority of doctoral students inside the RTG. This explains why students inside the RTG actually needed the same time to complete their doctoral degree while being less burdened with additional tasks and discontinuations than students outside the RTG. Therefore we cannot conclude that as regards the time to the doctorate the doctoral training inside the RTG was more effective than doctoral training outside the RTG.

Annex

Table 3.11 Evaluation of supervision

	Arts and humani ties/social sciences		Life sciences		Natural sciences		Engineering		Total	
	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG	Inside RTG	Outside RTG
Frequency of supervision[a] ***(in %)***										
While choosing the dissertation topic	78	77	77	73	82	83	63	60	76	77
While working on the dissertation	70	66	65	62	70	74	65	56	68	67
While finalising the dissertation	71	74	73	65	78	75	68	74	73	73
While preparing the oral examination	71	80	75	62	74	69	70	80	72	73
n = 100 %	*150*	*148*	*59*	*60*	*183*	*225*	*97*	*64*	*489*	*497*
Quality of supervision[b]										
…while choosing the dissertation topic										
Mean	2.4	2.5	2.6	2.4	2.4	2.3	2.7	2.8	2.5	2.4
Median	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.0	2.0
…while working on the dissertation										
Mean	2.4	2.6	2.5	2.7	2.1	2.2	2.9	2.6	2.4	2.4
Median	2.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	2.0
…while finalising the dissertation										
Mean	2.5	2.5	2.7	3.0	2.2	2.4	2.8	2.5	2.5	2.5
Median	2.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0

…while preparing the oral examination										
Mean	2.9	2.8	3.0	3.1	2.7	2.8	3.2	2.9	2.9	2.8
Median	3.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0
n	*166*	*154*	*61*	*63*	*194*	*231*	*100*	*70*	*521*	*518*
Support of supervisors[c]										
…publication of intermediary results										
Mean	3.5	3.4	2.4	2.8	2.4	2.2	3.0	2.7	2.9	2.7
Median	3.0	3.0	2.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0
…participation in conferences										
Mean	3.3	3.4	2.1	2.6	2.0	2.2	2.6	2.2	2.5	2.6
Median	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
…contacting scientists in Germany										
Mean	3.4	4.0	3.0	3.2	2.8	2.8	3.6	3.0	3.2	3.2
Median	3.0	4.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0
…contacting scientists abroad										
Mean	3.8	4.2	3.4	3.4	2.9	3.0	3.8	3.2	3.4	3.4
Median	3.0	5.0	3.0	3.0	2.0	3.0	4.0	3.0	3.0	3.0
n	*166*	*154*	*61*	*63*	*194*	*231*	*100*	*70*	*521*	*518*

Data source: CHEPS PhD-Survey 2005, own calculations
[a]% of PhD students indicating an adequate number of supervisions
[b]On a scale from 1 = mainly productive to 5 = mainly unproductive
[c]On a scale from 1 = to a high extent to 5 = not at all

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Chapter 4
The Interplay of New Public Governance Dimensions and Their Effects on Academic Outcomes

The Example of PhD Education in Economics Departments in Continental Europe, England and the US

Peter Schneider and Dieter Sadowski

4.1 Introduction

The idea of a structured education of future researchers was established in the US long before any European countries initiated similar attempts in the early 1990s. The apparent success of US research universities in placing their PhD graduates in top research institutions worldwide highlights the success of their educational system (cf. Bonaccorsi in this volume). But there are some European universities who also achieve remarkable placement success. The question then is what the organisational and institutional conditions for success at producing recognised researchers are. The question is all the more important for economics, the subject we focus on, as at least here not only future, but also current knowledge production heavily depends on doctoral research (Fabel et al. 2002). In our study of governance regimes we look at the interplay of intensity of competition driven by external incentives – and of the degree of a centralised, non-collegial decision-making in departments and universities. Both mechanisms are closely connected. For example, ample financial resources are only conducive to a successful PhD education as long as they meet favourable organisational preconditions (Schneider and Sadowski 2010). Given the sometimes narrow perspective of New Public Management (NPM) promises and bench-marks (Clark and Ma 2005; Frackmann 2005; Gumport 2005;

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Harley et al. 2004; Orr 2005) a configurational analysis is appropriate that does not exclude traditional or idiosyncratic organisational arrangements from the beginning.

In our theoretical sample we roughly distinguish three governance regimes, whereby each of these regimes still allows wide variations in structure and success rates: Continental Europe, England and the US.

Different pictures emerge from our analysis which, due to a lack of systematic data, is inevitably exploratory in nature: On the one hand, the highly competitive system of US research universities appears quite successful, but a recent debate indicates growing problems in their PhD education (Altbach 2004; Moes 2003; The Economist 2005). On the other hand, politically initiated reforms in Europe, such as the Research Assessment Exercise (RAE) in Great Britain, facilitate departmental placement success (Hammen 2005). The "Mapping of Excellence in Economics" (European Commission 2004) and the recent research grant allocations by the European Research Council (2008) both demonstrate success for universities in countries that were relatively early to adopt aspects of the US system. These early reformers are universities in the Netherlands and Great Britain. The success of countries that have adopted reforms more recently, such as Germany with its "Initiative for Excellence" (BMBF 2005), France with its new Elite Schools at Toulouse and Paris (LRU 2007), or Austria (Lanzendorf 2006), is not yet certain or visible (de Boer et al. 2007).

4.2 Governance Structures of Higher Education

Until the mid 1980s, the common governance model of most Continental European universities combined academic self-governance and high levels of state regulation and control. Since then, New Public Management initiatives have aimed for less state regulations and more "quasi-market" elements (Kehm and Lanzendorf 2006a). It is claimed that, concerning internal affairs, more autonomy through managerial hierarchies will enable universities to cope more efficiently with the newly induced competitive pressure.

Early analyses of higher education systems took a macroperspective to explain governance differences between countries. Clark (1983) distinguished three dimensions of coordination: market, state, and academic oligarchy. He later extended the framework with 'hierarchy' as a fourth dimension (Clark 1998). Van Vught (1997) classified governance in a two-dimensional model of state control and state supervision. McDaniel (1996), however, suggested that understanding the governing structure of higher education institutions cannot be conducted with broadly measured country-based differences. Thus, he rather demands a close look at the particular instruments used and the intensity with which they are applied. With their recent typology, de Boer et al. (2007) examine relevant governance types for higher education and distinguish five basic governance dimensions: **competition**, **academic**

self-governance, **stakeholder guidance**, **state regulation**, and **managerial self-governance**. These governance dimensions serve as the basis for our own study.

Taking these five dimensions and allowing in each dimension only either a "low" or a "high" value, Schimank (2007) distinguishes two ideal systems of governance in universities: The "perfect" new governance of universities combines high competition, low academic self-governance, high stakeholder guidance, low state regulation, and high managerial self-governance. A "perfect" traditional governance model shows the exact opposite values in each of these five governance dimensions.

In European reality, even policy regimes with the longest experience in implementing these NPM instruments like Great Britain (Leišytė et al. 2006) or the Netherlands (de Boer et al. 2006) have not reached "perfect" NPM governance yet. Latecomer countries such as Germany (Kehm and Lanzendorf 2006b) and Austria (Lanzendorf 2006) have only implemented some NPM instruments thus far (de Boer et al. 2007). German universities and departments experience steering attempts by many political actors. Sometimes these attempts are contradictory or at least inconsistent. For example, while the Federal Government introduced more competition with the 'Initiative for Excellence', a form of indirect or distant steering (BMBF 2005), the German Federal States imposed direct regulations, e.g. as to the particular design of PhD education (ENB 2008). As Schimank (2007) and de Boer et al. (2007) have demonstrated, configurations of pure traditional models as well as pure NPM models are extremely rare. High academic quality also occurs among "mixed" governance regimes[1] – at least according to NPM standards. The NPM-standards presume that the effectiveness of governance regimes depends upon the intended results and that a certain combination of governance elements might be favourable for one academic performance indicator (e.g. PhD placement in the general labour market), while another governance regime might be conducive to another performance indicator (e.g. publication record of PhD students). In any case, higher education institutions demonstrate different paces in changing their governance structure, which results in heterogeneous patterns of higher education governance between and within countries (de Boer et al. 2007).

The research in the governance of PhD education for Continental Europe and Great Britain is very limited. However, it is clear that even in the countries with the most extensive governance reforms, namely Great Britain and the Netherlands, reality is far from the ideal NPM model (Metcalfe et al. 2002; Park 2005; de Weert 2004). While very few NPM instruments are used in the governance of PhD education in Italy (Moscati 2004), some other European countries are experimenting with these tools: France (Lemerle 2004; Dahan 2007), Switzerland (Groneberg 2007: 19–21) and Germany (Hüfner 2004).

[1]According to Combes' and Linnemer's (2003) weighted ranking of publications, the Toulouse School of Economics (France), which operates under a suboptimal governance regime, is ranked 1st; the London School of Economics (England), operating in a governance regime very close to "perfect" NPM criteria, is ranked 2nd for publications in Europe.

4.3 Governance Dimensions

To assess the relation between governance initiatives and their outcome on PhD education, we rely on the framework of governance dimensions in the higher education sector as outlined by de Boer et al. (2007). We identified indicators for the respective governance dimensions to represent their potential impact on faculties to initiate PhD education.

(a) *Competition*

One of the main governance mechanisms in NPM is the implementation of (quasi-) markets (Kehm and Lanzendorf 2006a), which presumably explain the success of departments in US universities (Backes-Gellner 1992; Aghion et al. 2010). Some European countries, such as the Netherlands or Great Britain, have implemented transparent funding models that distribute research budgets according to academic performance criteria (European Commission 2004; Hammen 2005). Other Continental European countries, such as Germany, France and Italy, retain traditional budgeting rules with the addition of a few NPM instruments.[2] Additionally, a different focus on the recruitment practices for PhD candidates exists. The more departments aim on recruiting PhD candidates in an almost global market, the more they demonstrate academic self-confidence. Global recruitment requires that departments communicate their academic strengths against an expanded set of competing departments.

Additional funding based on locally competitive performance includes two different funding schemes. The first scheme is characterised by low threshold criteria where public authorities or universities determine relevant academic indicators, such as the amount of undergraduate teaching, time to degree or gender equality, and then reward above threshold results with a certain amount of money (Leszczensky and Orr 2004). For PhD education, these indicators include measures such as the total number of graduating PhD students, female/male-ratios or the overall number of postdoc positions created (Leszczensky and Orr 2004). Political actors put out to tender research projects that only address departments of a certain region – often with political expectations in mind. Here, competition is there but rather limited in scope.

Additional funding based on nationally competitive performance is a very strict version of administered competition and highly competitive. It is generally conducted on a national basis, employs peer reviews and demands the collective efforts of one or more departments. In Germany, for example, "Research Training Groups" or "Collaborative Research Centres" use an extensive funding to significantly alter the traditional master-student PhD education. The result is a new way to integrate the doctoral students into the scientific community. Successful

[2] The majority of the German Federal States, for example, have established a regime of quasi-competitive elements where they first required university departments to cut their basic resources with the objective to establish a research foundation that will redistribute these savings according to a prospective reward system (Leszczensky and Orr 2004).

participants in the market for highly competitive third-party funding are more able to support their PhD candidates with scholarships, travel grants and opportunities to engage in scientific activities (DFG 2000: 15–16; DFG 2003: 30).

The ways different departments recruit PhD students vary to a great degree and reflect their competition for the best PhD students. Departments and supervisors have different expectations and criteria. In Germany all universities can award PhDs. However, some departments clearly emphasise undergraduate teaching while others focus on graduate training. When social skills and personal likings dominate selection decisions, the recruitment of PhD students often originates in the supervisors' undergraduate classes or through recommendations by peers.

In contrast, when a department pursues high quality research, its professors search for PhD students who show the demonstrable potential to master methodological skills and a theoretical background. The stronger the research commitment of a department is, the wider the scope for attracting and recruiting PhD students is. PhD students serve as a source of improving research and the research reputation of the department (Breneman 1976).

(b) *Managerial Self-Governance/Hierarchy*

Regulations concerning PhD education can be imposed by university management on departments with regard to selection procedures, programme size, the maximum length of studies, and the extent of international collaboration.

Although widely criticised (e.g. Frey 2007), the ranking of academic standing has attained cult status and allows transparency over academic achievements. University management may demand publication records on a regular basis. It also has more profound evaluations to assess the academic activities of departments and their members. Accreditations and audits are two particular instruments available to assess a department's activities (Harvey 2004; Stensaker 2000; Stensaker and Harvey 2006).

Although Schimank (2006) pessimistically pictures the effectiveness of target agreements as a means of governing universities and departments they are a popular governance instrument in higher education (Jaeger et al. 2005; Weichselbaumer 2007). Elsewhere their efficacy has been demonstrated for judges who face a complex task and various performance criteria (Schneider 2007). Evaluating academia may be even more challenging as there are many and diverse performance criteria. In addition, the research performance is often only observable after a significant period of time (Schneider and Sadowski 2004: 395).

(c) *State Regulation*

The academic behaviour of departments and individuals can also be guided by public policy. For example, regulations may require a certain ratio of foreign-to-domestic PhD students in a programme (ENB 2008); or financial assistance or impacting the tax treatment of that assistance may depend on certain conditions. Even the legal status of PhD students in a country can be a matter for public policy (de Weert 2004).

(d) *External Stakeholders*

External interest groups can also influence the direction of PhD education. Such influence – be it anticipated or manifest – is reflected in the importance of league tables as a performance criterion. Changes in a department's rank and the desire to change a department's rank may have a stronger impact on the faculty behaviour than laws and direct regulations may have.

From our interviews we quote two examples for the varied importance of external stakeholders:

An example where external stakeholders are highly important:

> … And particularly, whenever there is a new ranking and it says the economists of xxx are super – today that's more important then ever… (professor; Continental European department)[3]

An example where external stakeholders are of less importance:

> … it's not worth it whether we are ranked 30 or 20. It's important to ascend from 30 to top 10 but we cannot finance this leap, we don't have the resources. It doesn't matter. I only know of two economics departments who have managed to do this step within the last ten years. … The reward of rankings is rather indirect. It's a signal: 'take a look, we are good.' Nothing really depends on the rankings… (professor; US department)

(e) *Academic Self-Governance*

Academic self-governance captures the degree of autonomy a department has in decisions regarding new hires, budgets – and the design of PhD education.

An example of little autonomy in PhD recruitment:

> …there are a lot of them in the administration, they do all the screening of the documents [of PhD candidates] for us … yes, and even the selection of professors is all done by them in the head office… (professor; Continental European department)

An example of autonomy in a faculty's hiring decisions:

> …The economists [in the faculty] took up a stance very early and favoured the xxx criteria for the selection of new candidates. … The economists have thought it over for quite a while already how to position themselves strategically and so far it worked out… (professor; Continental European department)

An example of autonomy over the budget:

> … I have a global budget of xxx and I can switch between personnel or other expenses, I am pretty much autonomous… (professor; Continental European department)

An example of little autonomy over the budget:

> … I have half of a percent of the salary rate to work with and this is very little, I mean, you cannot do very much with that. It is the modest increments… (chairman; US department)

An example of autonomy in the design of education:

> … No, they [university management] don't interfere. I mean they try to interfere with the new master and bachelor classes but not in the way that they say like this or this, they just want to have them look alike…(professor; Continental European department)

[3] If necessary, the original statements were translated into English by the authors.

An example of little autonomy in the design of education:

> ..but we are not so autonomous that we can do all by ourselves. Only after consultation with the boards…(professor; England department)

Every interviewee indicated that university management either consults the faculty board or that the faculty has a big say in the decision-making of a department. In general, the autonomy of the faculties is greater for academic than for organisational matters. Below, the five governance dimensions and their corresponding indicators are summarised.

- competition
  - additional funding based on locally competitive performance,
  - additional funding based on nationally competitive performance,
  - competition for PhD students.
- managerial self-governance/hierarchy
  - transparency of academic achievements,
  - university regulations for departments,
  - target agreements.
- state regulations
  - direct interference in PhD education,
  - legal regulations for departments,
  - external stakeholders,
  - departmental rankings in league tables,
  - university board.
- academic self-governance
  - faculty influence in strategic decision making.

For our empirical study we share the already quoted assumptions of Schimank (2007) and de Boer et al. (2007) and claim that it might be the interaction of several governance mechanisms that determines the outcome (similarly Braun and Merrien 1999: 19). We pose this particular question:

Which governance dimensions or combinations thereof lead to a successful PhD education?

4.4 Empirical Design

We focus on the producers of PhD education, namely university departments and their faculties. We assess how faculties perceive and experience their governance and we ask which governance configurations lead to high academic placements. Our selection of economics departments embraces different countries from three governance regimes to ensure a wide variety of governance systems.

We focus on departments in England to capture an exogenously generated competition through the Research Assessment Exercise (RAE). We presume that increases in competitive pressure generate new institutional stratifications with a new, more effective and/or efficient organisation of PhD education (Hammen 2005; Harley et al. 2004; Orr 2005). According to a "theoretical sampling", we choose two departments that generally have benefitted from the new system and three departments that have not changed their position in the RAE, although they improved in international research rankings.

We sampled US research universities, because there the differentiation of universities is much more advanced and established than in Europe. The competition between private and state universities has a long tradition and is taken for granted (Frackmann 2005; Lombardi et al. 2004; Graham and Diamond 1997). Different organisational settings answer to such competitive challenges and should include PhD education (Graham and Diamond 1997: 174). Private research universities usually lead the rankings of top departments (Goldberger et al. 1995; Thursby 2000). It seems plausible that they also organise PhD education most successfully.

Departments from Continental Europe reflect a wide variety of different governance systems with scattered patterns of market elements and state regulation.

Within the governance regime approach, we argue with Mayntz (2005) that departments operate in a unique (local) governance "system of rules" that offers a set of incentives and consequences which lead to a particular form of PhD production and publication output as 'corps d'esprit'. We therefore selected departments not only according to their governance regime, but within the respective regime according to their academic success, measured by quality-weighted publications according to Combes and Linnemer (2003).

For the analysis we employ the five governance dimensions described above as the input conditions,[4] whose configuration determines the academic placement success of the department's PhDs.

In our explorative case study, we rely on in-depth interviews and combine them with document analyses. Interviewees were asked whether and to what degree they perceive an influence of either one of the governance instruments under consideration, in particular regarding the department's PhD education. We interviewed several participants in each department to keep reliability in the statements.

4.4.1 Sample

For our study, we planned to realise a very heterogeneous sample between and within governance regimes in order to represent the different levels of governance. To realise a sample in a regime with traditionally strong market exposure, we selected eight departments in the US. In order to realise a sample in a transitional

[4] In order not to confuse the basic assumptions of statistical methods with Qualitative Comparative Analysis (QCA), we use the term "condition" instead of "independent variable".

regime where high market exposure was just recently established for the entire higher education system, we chose five departments in England. Finally, we selected 13 departments in Continental Europe to realise a sample that exhibits high levels of state control.

Table 4.1 characterises our sample of 26 departments along two dimensions: the academic success according to the publication record of Combes and Linnemer (2003) and the governance regimes: US, England and Continental Europe. The departments are indicated D1 to D26.

The department size varies from 6 professors to 79 professors. The overall median of faculty is 23.5 professors and the overall mean number of faculty is 28.0 professors, with a standard deviation (SD) of 21.0 professors. There are variations as Table 4.2 demonstrates.

We identified the average annual number of graduating PhD students from the web pages and from information by the programme administrators. The average number of PhD graduates varies from 2.0 graduates to 24.8 graduates annually with a mean of 8.4 PhD graduates (SD = 5.9) and a median of 5.6 PhD graduates. Table 4.3 shows the sizes for our subsamples.

Table 4.1 Sample according to governance regimes and publication record

		Publication record	
		High	Low
Governance regime	US	D15, D17, D26	D16, D18, D19, D20, D21
	England	D11, D23, D24, D25	D22
	Continental Europe	D1, D5, D9, D10 D12, D13, D14	D2, D3, D4, D6, D7, D8

US United States of America, *High* publication output of the department is among the top 150 departments (Combes and Linnemer 2003), *Low* publication output of the department is not among the top 150 departments (Combes and Linnemer 2003), *D1 to D26* departments in our sample

Table 4.2 Department size according to regions

	Span	Mean	SD	Median
Overall	*6–79*	*28.0*	*21.0*	*23.5*
Continental Europe	6–58	14.7	13.9	10
England	26–48	29.6	13.5	32
US	18–79	47.0	21.0	47.5

Span lowest to highest number of faculty members in the departments, *mean* mean value of faculty members, *SD* standard deviation of faculty members, *median* median value of faculty members

Table 4.3 Programme size: annual number of graduating PhD students according to regions

	Span	Mean	SD	Median
Overall	*2.0–24.8*	*8.4*	*5.9*	*5.6*
US	2.0–16.7	6.7	4.9	4.6
England	3.8–16	10.5	6.5	14.4
Continental Europe	2.6–24.8	9.1	8.1	5.8

Span lowest to highest number of PhD students in the departments, *mean* mean value of PhD graduates/year, *SD* standard deviation, *median* median value of PhD graduates in the departments

Between May 2005 and March 2008 we conducted semi-structured in-depth interviews with 81 academic and administrative key persons at the respective departments. We investigated the governance of a variety of their daily academic activities such as administration, teaching, research in general, and PhD education in particular for the years 2001–2002. To avoid biased answers, we left the interviewees unaware of our definition of a successful department. We asked them to compare the governance styles in 2001 and 2002 to the ones predominant at the time of the interview. We were interested in their perception of individual and departmental effects. The indicators of each governance dimension were scrutinised for each case and then related to the outcome, i.e. academic placements for the years 2002–2006.

4.4.2 Analysis

In order to analyse the interview statements we use "fuzzy set Qualitative Comparative Analysis" (fsQCA) by Ragin (2008) and the QCA software by Ragin et al. (2006). For our research question, the fsQCA is the method of choice. In contrast to classical statistical models such as Regression Analysis that deliver "unifinal" results represented in one single regression equation, the fsQCA allows "equifinal" results, meaning that different conditions may lead to the same outcome.

4.4.2.1 Outcome Condition

The criteria for performance measurement of PhD education are manifold (Colander 2008). While several approaches focus on qualitative aspects, such as the publication record of PhD graduates (Hilmer and Hilmer 2007) or professors (Rauber and Ursprung 2008), or the reputation of a graduate school (Ehrenberg 2004; Burris 2004), quantitative criteria such as the total number of graduates (Leszczensky and Orr 2004) or the time to degree are also considered indicators for success.

The present study takes a quality approach and assesses the impact of PhD education for the academic market. We avoid data which are watered down due to long-time lags in publications by PhD graduates early in their career and use a composite qualitative measure based on PhD placements instead (Schneider and Sadowski 2010). PhD education is considered to be academically relevant when the department manages to place PhD graduates in universities as postdocs or assistant professors. We are aware of other legitimate views of what constitutes a successful PhD education. In a few countries, doctoral degrees carry some weight outside academia. Here, PhD students sometimes consent to maintain daily teaching, administrative, and research routines of a department. Where students have a genuine scientific interest they will meet with the faculty that shares this research orientation. If successful, academic placements are a natural consequence that will be reflected, in the long run, through publications, scientific progress, and reputation for the departments of origin.

As one of our interviewees illustrates:

> "PhD programmes… to train the next leaders of academia … and basically I think the way you do that is to bring quality to the programmes: students, faculty and the research" … "few – not many [PhD graduates] go to corporations … the business schools, they have many people in corporations, we tend not to." (dean; US university)

For the present study we claim that PhD education has the highest academic impact when departments manage to place graduates in top university departments and the least impact when PhD students are not placed in an academic position. Between these two extremes, departments display varying degrees of placement success. To obtain the placement records, a dataset was created, which identified the names of all PhD graduates of the sample departments[5] for the years 2002–2006. Each individual career was then followed.[6]

We did not simply count the number of placements in academia. While many German departments, for example, employ PhD students predominately to maintain their daily routines, English or US departments are explicitly geared towards the high end of the academic labour market. We capture quality differences by the ranking positions of the hiring departments. The higher ranked the hiring department is, the more emphasis was presumably on the academic perspective of a candidate. If a hiring department belongs to the top 150 research departments or centres in the world corresponding to the study by Combes and Linnemer (2003), we code this as a distinguished placement qualifying the overall placement rate.

In our sample, the placement ratio varies between 0.03 (3 % of PhD graduates find a position as postdocs or faculty in the academic sector) and 0.76 (76 % of PhD graduates find a position as postdocs or faculty in the academic sector). The mean value for placements is 0.41 and the median 0.42. The placement ratio in top departments varies between 0 (no PhD graduate is placed in a top department) and 0.43 (43 % of PhD graduates are placed in a top department), the mean value being 0.13 and the median 0.11.[7] Table 4.4 summarises the data for all governance regimes according to general placements and placements in top departments.

For the fuzzy set "calibration" we clustered the departments in a six-value fuzzy set (Table 4.5). The score includes two intermediate levels (mostly but not fully in = 0.8; more or less in = 0.6) between the breakpoint (0.5) and fully in (1) on the left. On the right, it shows two intermediate levels (more or less out = 0.4; mostly but not fully out = 0.2) between the breakpoint (0.5) and fully out (0) (Ragin 2008: 31). Departments are considered 'fully in' when they display high levels of general and qualitative placements. The department D11, for example, has for each time period (continuously) an average of general and top placements of more than 50 %, which in our eyes qualifies for a membership score of 1. The department D9 with a

[5] We were not able to obtain the names from one department. There we relied on the statements of our interviewees about placements.

[6] Amir and Knauff (2008) point to the high correlation between placement success of PhD graduates and the academic level of the departments they graduated from.

[7] General placement and qualitative placement correlate with $r = .47$ ($p = .05$); $N = 25$ (one case missing).

Table 4.4 PhD placements as postdocs

	Span (%)	Mean (%)	SD (%)	Median (%)
General placements				
Overall	3–76	41	21	42
US	23–76	54	18	49
England	10–71	47	21	54
Continental Europe	3–60	31	17	26
Placements in top departments				
Overall	0–50	14	14	17
US	0–43	12	15	3
England	0–50	23	18	21
Continental Europe	0–32	13	12	16

Span lowest to highest number of PhD students in the departments, *mean* mean value of PhD graduates/year, *SD* standard deviation, *median* median value of PhD graduates in the departments

Table 4.5 Fuzzy scores for the outcome condition

Membership score	1	0.8	0.6	0.4	0.2	0
Verbal specification	Fully in	Mostly but not fully in	More or less in	More or less out	Mostly but not fully out	Fully out

membership score of 0.8 (mostly but not fully in) continuously displays a general placement score of more than 50 % and discontinuously in the top score of 25 %. A membership score of 0.6 (more or less in) is assigned to departments such as D23, which has a general placement score of 40 % and the discontinuous top placement score of 20 %. The department D24 has a membership score of 0.4[8] (more or less out) and reaches a general placement of 70 % but no top placement. A membership score of 0.2 (mostly but not fully out) is assigned to departments such as D16 (general placement 0.42, a sporadic top placement 5 %). Finally, departments like D26 (discontinuous general placement 23 %, no top placement) are considered to be 'fully out'.

4.4.2.2 Input Conditions

All five governance dimensions, with their respective indicators as illustrated above, serve as input conditions. The coding varies between 4 and 6 fuzzy scores. The configurations of all conditions for each case are shown in the fuzzy data table (Table 4.7). As intended, there is a great variety in the governance of departments.

Competition: The departments face competition on many different levels. We distinguish the degrees of membership in the competitive set through a six-value

[8] The data for one department was missing. We assigned them a membership score of 0.4, based on the statements of our interviewees.

fuzzy-set. The departments' degree of competitiveness is determined according to their evaluation of the interviewees of their environment and the aspiration level of the reported goals.

The departments are located between the point of maximum ambiguity (0.5) and full membership (1.0) when they compete for nationally competitive funding, since national competitive funding implies a very intensive competition and is based on peer reviews. The departments are always located between the point of maximum ambiguity (0.5) and non-membership (0.0), if they do not compete for national competitive funding.

Based on the statements of our interviewees, we calibrated the following fuzzy values (Table 4.6). We assign full membership (1.0) when they regularly apply for national and local competitive funding and when they compete for the best PhD students worldwide. Departments are assigned a strong membership in the fuzzy set (0.8) when they often apply for national competitive funding, regularly apply for local funding and when they deliberately limit themselves to compete for the best PhD students nationally. When departments occasionally apply for national funding, often apply for local funding and focus on the best PhD students in their department and occasionally on a national level, they are assigned to be more or less in (0.6).

The departments are assigned to be more or less out (0.4) when they do not compete for national funding but often apply for local competitive funding and limit themselves to PhD students from their own lectures or classes. They are assigned a weak membership (0.2) when they do not compete for national funding, when they limit themselves to occasional local competitive funding and recruit PhD students from their own classes. When departments join hardly any academic competition, neither national nor local, and focus on local PhD students, they are assigned a full non-membership (0.0).

Hierarchy: The departments face different degrees of hierarchy. We distinguish a six-value fuzzy set to assess the hierarchy in a department.

We assign the full membership to the fuzzy set (1.0) when a dean is a professional manager, has strategic discretion, and has the ultimate right to decide upon new hires. Additionally, strong deans can require minimum performance standards

Table 4.6 Fuzzy scores for the condition: competition

Fuzzy score					
1	0.8	0.6	0.4	0.2	0
Verbal specification					
Regular national competition	Often national competition	Often national competition	No national competition	No national competition	No national competition
Regular local competition	Regular local competition	Often local competition	Regular local competition	Occasional local competition	No local competition
Worldwide PhD recruitment	National PhD recruitment	National PhD recruitment	Local PhD recruitment	Local PhD recruitment	Local PhD recruitment

Table 4.7 Fuzzy data table of governance dimensions and their output for 26 departments

Competition	Hierarchy	State regulation	External stakeholders	Academic self-governance	Outcome	Department
0.8	0.2	0.66	0.66	0.8	0.8	D1
0.2	0.2	0.66	0.33	0.8	0	D2
0.2	0.2	1	0.33	0.6	0	D3
0.4	0.2	0.66	0.33	0.8	0.2	D4
0.6	0.2	0.66	0.33	0.8	0.6	D5
0	0	0.66	0	1	0	D6
0	0	0.66	0.33	1	0	D7
0	0	0.66	0	1	0	D8
0.8	0.4	0.66	0.66	0.6	0.8	D9
0.8	0.2	0.33	0.33	1	0.6	D10
1	1	0	1	0.6	1	D11
0.8	0.6	1	0.66	0.2	1	D12
0.4	0.8	1	0.33	0	0.6	D13
0.8	0	0	0.66	1	0.8	D14
1	1	0	1	0.4	0.6	D15
0.2	0.4	1	0	0	0.2	D16
1	1	0	0.66	0.4	1	D17
0.2	0.4	0.66	0.33	0.2	0.4	D18
0.2	0.4	0.66	0.33	0.2	0.4	D19
0.4	0.4	0.66	0.33	0.2	0.6	D20
0.4	0.6	0.33	0.66	0.4	0.4	D21
0	0.4	0.66	0	0.2	0	D22
1	0.8	0	1	0.6	0.6	D23
0.6	0.6	0.33	0.66	0.6	0.4	D24
0.6	0.6	0.33	0.66	0.6	0.6	D25
0.4	0.4	0.66	0.33	0.2	0	D26

Each value in each cell indicates the fuzzy value of the input (governance dimensions) and output (placement) condition of each case (department); D1 to D26: departments in the sample

and impose sanctions on failing faculties. The departments are assigned a strong membership (0.8), when the dean or the department head has established strong organisational regulations for PhD education binding individual professors, and in case of violation may impose sanctions on faculty members – without implying that the strategy itself is imposed. We assign the departments to be more or less in than out (0.6) when deans manage the organisation of a department and have a certain behavioural flexibility, for example, negotiating work loads. They may be either professional managers or are able to renew their turn as dean again and again.

The departments are assigned to be more or less out (0.4), when deans are elected from the faculty and have a small discretion in important decisions. A weak membership (0.2) is assigned when faculties are autonomous in their daily activities, but where a dean as *primus inter pares* is elected to negotiate the interest of the faculty with the university management. The departments are assigned a full non-membership (0.0) when faculties are autonomous in their individual decisions of how to organise research and teaching without feeling hampered by a dean.

State regulation: In order to capture different degrees of state regulation we chose to distinguish a four-value fuzzy set.

The departments are assigned a full membership (1.0) when states directly interfere in the autonomy of PhD supervisors and determine the remuneration of students, the proportion of foreign students, or the organisational status of PhD students. We consider the departments to be more in than out (0.66) when states indirectly influence education, for example through the regulation of PhD instruction.

When the state only sets a certain frame, e.g. for eligibility for scholarships, we consider the departments to be more out than in (0.33). A full non-membership (0.0) is assigned when there is no state influence on any element of PhD education.

External stakeholders: The different degrees of influence exerted by external stakeholders are also reflected by a four-value fuzzy set.

Originally we planned to consider university boards and rankings in league tables. However, not a single interviewee indicated any influence of university boards on supervisor activities or on the design of the PhD programme on the departmental level. Thus, we dismissed the board dimension and relied solely on the perceived importance of a department's position in league tables as an indicator of the power of external stakeholders.

The departments are assigned a full membership (1.0) when the position in international league tables is of paramount interest in departments and activities focus on maintaining a good ranking or rising in the ranking. We consider the departments to be more in than out (0.66), when the relative ranking on a national level or with a few significant international departments is of major concern and induces investment in academic activities.

When only national rank orders are considered as relevant, we assign the departments to be more out than in (0.33). A full non-membership (0.0) is assigned when interviewees reported that rankings have no weight on their actions.

Academic self-governance: To assess the extent of academic self-governance, we coded our observations with the help of a six-value fuzzy set. We based our calibration on three indicators: the freedom of writing job descriptions for new hires, the allotment of the faculty budget, and the degree of joint decision-making upon the design of PhD education.

When a faculty is free in its decision of how to write a job description for a new hire, independently decide upon a budget and jointly agree upon PhD education, we assigned a full membership (1.0). The departments are assigned a strong membership (0.8) when interviewees indicate that faculties can decide upon almost all tasks for a new job hire, has at least a small budget to decide upon autonomously and jointly agrees upon PhD education. We assign departments to be more in than out (0.6) when a faculty can decide upon almost all elements of new hires but has no budgeting autonomy or common agreement on the design of PhD education.

The departments are assigned to be more or less out (0.4) when they have input into the job description but do not determine the allocation of their budget and are not free to decide how to train PhD students.

A weak membership (0.2) is assigned when faculties have very little input into the writing of job descriptions, do not determine the allocation of their budget, but are able to decide how to train PhD students.

A full non-membership (0.0) is assigned when faculties have no official role in the production of the job description, do not determine the allocation of the budget and are not free to decide how to train PhD students.

4.5 Results

For the academic placement of PhD graduates, our outcome condition, fsQCA delivers one necessary condition, three sufficient configurations of NPM instruments and one – sufficient – solution based on "prime implicants", a technical term in QCA denoting maximally reduced configurations to explain success in PhD education (outcome = 1). The solution of the necessary condition is depicted in Table 4.8 and the solution of the three sufficient configurations along with the prime implicants (fourth sufficient solution) is shown in Table 4.9.

A test for necessary conditions indicated a high consistency score (consistency = 0.914) and a high coverage score (0.828) for the presence of competition coverage measures the proportion of cases that are covered by a certain configuration. Without competition for highly sought-after funds and/or top PhD candidates, there is almost no placement success. That is the strongest result we have: Only in 1 out of the 13 successful departments, faculty members considered themselves not to live in a competitive environment. The other four conditions reveal consistency scores below 0.782 and coverage scores below 0.764, thus indicating that these conditions are not necessary for the success in placing PhD graduates.

Table 4.8 Necessary condition

–	Consistency	Coverage
Competition	0.914	0.828

Table 4.9 Configurations for academically successful PhD education, logical remainders excluded

Configuration										Raw coverage	Unique coverage	Consistency
1	C	●	h	●					A	0.500	0.224	0.853
2			H	●	s	●	E	●	a	0.442	0.022	0.875
3	C	●	H	●			E	●	a	0.505	0.063	0.889
4	C	●			s	●	E	●	A	0.534	0.052	0.895
Solution coverage: 0.803												
Solution consistency: 0.859												

c competition, *h* hierarchy, *s* state regulation, *e* external stakeholders, *a* academic self-governance. CAPITAL letters indicate presence of condition, lowercase letters indicate absence of condition; ● = logical AND. Solution coverage/consistency scores include prime implicants

Again we included all 26 cases for the examination of sufficient conditions. We chose a frequency cut-off of 1 and determined a consistency cut-off of 0.80.[9] This left us with 13 cases with outcome 1. Logical remainders were excluded and prime implicants were chosen by hand. Two additional configurations arose when choosing prime implicants by hand. We opted for the configuration with the higher consistency score (0.895) as can be seen in configuration 4 in Table 4.9.

The results demonstrate that beyond the necessary pre-requirement of competition there are four sufficient configurations concomitant with placement success. One subset of departments (configuration 1 in Table 4.9) faces a governance pattern in which a high level of competition, low managerial self-governance and high academic self-governance are sufficient for a successful PhD education. This first sample comprises five successful departments from Continental Europe.

The second subset of departments (configuration 2 in Table 4.9) achieves success under a governance system with a high level of managerial self-governance, low state regulation, a high focus on external stakeholders and low levels of academic self-governance. Based on the present sample, these are three departments that roughly follow the standards of US research universities. These departments are from the US and Continental Europe. Subset 3 (configuration 3 in Table 4.9) consists of very similar sufficient conditions and departments for a successful PhD education to occur. Yet in this subset, where two departments are located in the US and one in Continental Europe, the departments are more concerned with competitive pressures than those in the configuration before.

Selection of prime implicants by hand produced two additional configurations of prime implicants. We selected the configuration with the higher consistency score. This last subset of departments (configuration 4 in Table 4.9) displays a configuration of sufficient governance dimensions that consists of a high level of competition, low state regulation, a strong focus on external stakeholders, and a high level of academic self-governance. Based on the present sample, this pattern represents a cluster of five successful departments, predominantly from England, from Continental Europe, and from the US.

Our results show that there is not just one way of shaping academically successful PhD programmes. Both US and English (type) departments support academic performance, view configurations 2, 3 and 4. The same holds for those departments in our sample in Continental Europe that manage to create and operate in a governance system that comes close to the reference models of successful US and English (type) departments. Nonetheless, configuration 1 in Table 4.9 highlights an additional fact. As long as they confront competitive challenges, governance systems that exist in many countries of Continental Europe may also be compatible with a successful academic placement.

The question of why some departments fail to place their PhD graduates well is not necessarily answered by inverting the conditions of success. We therefore conducted an fsQCA for the opposite outcome: low academic placements.

[9] We chose 0.8 as the valid consistency score since our data revealed a consistency gap between 0.80 and 0.74 in cases 13 and 14.

A test for necessary conditions shows no clear picture for less successful departments. The absence of competition is the condition with the highest consistency (0.847) and coverage (0.924) scores, but the consistency score is too low to justify it as a necessary condition (>0.93).

The cases reveal high consistency scores for a less successful PhD education. We included all 26 cases for the analysis of sufficient conditions (complex solution), chose a frequency cut-off of 1 and determined a consistency cut-off of 0.93.

This left us with the 13 cases with the outcome 0. In the first step, logical remainders were excluded (including or excluding prime implicants in the analysis does not change the solutions). Two configurations arise with a solution consistency of 0.961 and solution coverage of 0.688, cf. Table 4.10.

The results of Table 4.10 demonstrate that the less successful departments are essentially characterised by only one unique configuration of conditions. This configuration (configuration 1 in Table 4.10) combines a low level of competition with a low level of managerial self-governance, high state regulation and little focus on external stakeholders. This configuration is present in 12 out of the 13 departments in our sample with a less successful PhD placement. It is observed under all governance regimes, be it in Continental Europe, England or the US. The additional pattern (configuration 2 in Table 4.10) originates from one single department with an almost inverse pattern to the majority one.

In contrast to the wide variety of governance configurations for successful departments, our findings indicate that less successful departments are characterised by one pattern of detrimental conditions. No condition itself is necessary for a low placement, yet in our sample their combination guarantees failure – granted our definite, but certainly narrow criterion of success.

The fuzzy data table (Table 4.6) indicates that the degree of each governance dimension varies enormously between and within the three governance regimes. On the other hand, it is not necessary for governance dimensions to vary greatly in order to result in a positive or negative outcome. A governance dimension may have a positive or negative effect on the outcome only when it crosses a certain threshold and combines with certain other governance dimensions. We can see, for example, that there is only a slight difference in the degree of membership for ‘competition’ between the departments D19 and D20 (see Table 4.7). Yet fsQCA reveals that in

Table 4.10 Configurations for academically less successful PhD education, logical remainders excluded

Configuration		Raw coverage	Unique coverage	Consistency
1	c ● h ● S ● e	0.660	0.430	0.960
2	c ● H ● s ● E ● a	0.258	0.028	1
Solution coverage: 0.688				
Solution consistency: 0.961				

c competition, *h* hierarchy, *s* state regulation, *e* external stakeholders, *a* academic self-governance. CAPITAL letters indicate presence of condition, lowercase letters indicate absence of condition; ● = logical AND. Solution coverage/consistency scores include prime implicants relation to the concomitant membership scores of all other departments, this difference is accountable for department D20 belonging to the cluster of successful departments and for department D19 belonging to the unsuccessful cluster.

Accordingly, the departments D4 and D5 exhibit a contrasting membership pattern to D19 and D20. Yet here again, as can be seen from Table 4.5, only the slight increase in the membership score for 'competition' in accordance to all the concomitant configurations of all other departments accounts for the department D5 to be a successful department and for the department D4 to be an unsuccessful department.

4.6 Robustness Checks

So far we have explored the impact of governance dimensions on the placement of PhD graduates. However, there may well be other conditions that influence the presumed causal connection between dimensions and the placement of PhD graduates. We now examine some natural candidates.

(a) *Overall Financial Resources*
Financial resources are considered crucial for effective graduate programmes. Unfortunately, comprehensive data on the overall financial budgets of departments were not available to us. We relied on published research budgets and third-party funding[10] as an imperfect proxy for a department's overall financial strength. The departments are clustered[11] in a six-value fuzzy set with two intermediate levels (mostly but not fully in = 0.8; more or less in = 0.6) between the breakpoint (0.5) and fully in (1), and with two intermediate levels (more or less out = 0.4; mostly but not fully out = 0.2) between the breakpoint (0.5) and fully out (0). The departments are considered 'fully in' when their research budget exceeds €1.2 million annually in the years 2001–2003. They are assigned a membership score of 0.8 (mostly but not fully in) when their annual research budget lies between €1.2 million and €900.000. A membership score of 0.6 (more or less in) is assigned for the range from €900.000 to €500.000. A membership score of 0.4 (more or less out) indicates a research budget between €500.000 and €250.000. A membership score of 0.2 (mostly but not fully out) is assigned to departments with a research budget between €250.000 and €1, and finally, departments which do not identify any research funding are considered to be 'fully out'.

Surprisingly, adding overall financial resources as an additional condition to the fsQCA does not change the test for necessary conditions. Competition remains the sole necessary condition for the outcome "success", cf. Table 4.8.

[10] All budgets were converted into €.

[11] The thresholds are based on a cluster analysis in TOSMANA (Cronqvist 2007), which is based on the budgets of the departments in our sample.

We also included all 26 cases for the analysis of sufficient conditions. We chose a frequency cut-off of 1 and determined a consistency cut-off of 0.88 due to large gaps between the consistency scores. This left us with 11 cases with outcome 1. Logical remainders were excluded.

Including the moderating condition ‘financial resources’ into the configuration with the five governance conditions improves the overall fit (consistency score: 0.88) of the entire model; for the individual configurations it results in an equal or even better fit. The underlying pattern of the influence of governance dimensions does not change significantly; the configurations are more or less represented by the same departments as before.

In a first step, the analysis was carried out with 11 cases due to the strict application of a consistency score of 0.88. In the original analysis we had 13 departments, so we assumed that the results could have only occurred based on the neglect of two cases. To scrutinise whether it was only the stricter consistency criteria that produced these results, we reduced the consistency criteria to a consistency score of 0.78, and reran the analysis. These results had about the same overall fit as in the original analysis (consistency score: 0.859), but, compared to the original analysis, the individual consistency scores improved.

(b) *Per Capital Financial Resources*

As an additional check on the robustness of our results, we included a proxy measure for per capita financial resources as a moderating condition. A cluster analysis suggested a six-value fuzzy set. The departments are considered ‘fully in’ and receive a score of 1 when the individual research budget exceeds €90.000. We assign a membership score of 0.8 when the individual research budget lies between €90.000 and €50.000. A membership score of 0.6 is assigned when the budget lies between €50.000 and €20.000. A membership score of 0.4 indicates a research budget between €20.000 and €10.000. A membership score of 0.2 is assigned to departments with a research budget between €10.000 and €1.000. Finally, the departments where individual professors have less than €1.000 available are considered to be ‘fully out’ with a score of 0.

Adding the individual financial resources as an additional condition does not change the result of the test for necessary conditions. Competition remains the only necessary condition. For the test for sufficient conditions we included all 26 cases, chose a frequency cut-off of 1 and determined a consistency cut-off of 0.79. This left us with 13 cases with outcome 1. Logical remainders were excluded.

The new results possessed the same overall fit (consistency score: 0.86) as both the original analysis and the analysis with only the (approximated) overall financial resources. However, the individual consistency scores were lower compared to those of the original analysis. There are two additional configurations consistent with placement success; this new complexity provides worse coverage scores for each configuration and for the solution coverage. Adding these conditions does not improve the original model of Table 4.9.

(c) *Previous Publication Record*

We assume that the publication record of supervisors makes an impact on the scientific potential of PhDs. In particular, Schneider et al. (2010) hint at the importance of publication records of PhD supervisors for placement success. Using the ranking of Combes and Linnemer (2003), we calculate internationally comparable publication records for US and European economics departments.

The departments are subdivided into four clusters:

Departments are assigned a full membership (1.0), when they are ranked between rank 1 and 35 in the ranking by Combes and Linnemer (2003). We consider departments to be more in than out (0.66), when they are ranked between rank 36 and 100. When they are above rank 100, departments are considered to be more out than in (0.33). And finally, according to the ranking of Combes and Linnemer, a full non-membership (0.0) is assigned when the departments are not ranked at all.

Adding the previous publication record of the departments as an additional resource condition to the fsQCA does not change the result of the test for necessary conditions. Competition remains the sole necessary condition for the outcome variable as indicated in the "Analysis of Necessary Conditions" of academic placements (in 4.5). To analyse sufficient conditions, we chose a frequency cut-off of 1 and used a consistency cut-off of 0.78 to make the sample comparable to the original analysis. This left us with 13 out of our 26 cases with an outcome of 1. Logical remainders were excluded, and one of two prime implicants, the one with the higher consistency score, was chosen by hand. This new analysis provides a very fragmented picture. Although the overall consistency score rose along with most of the individual consistency scores, these increases do not imply improved interpretable results. First, each configuration displays at least five underlying conditions leading to idiosyncratic explanations without sensible clusters. Second, the addition of three new configurations sacrifices parsimony and leaves seemingly arbitrary results. Third, an in-depth analysis of the distribution of the departments to the configurations does not lead to new clusters.

For many departments in our sample, a publication record is not a sufficient condition to explain placement success.

(d) *Total Number of Professors and Teaching Personnel*

As Hilmer and Hilmer (2007) or Osterwalder (2007) show, the number of supervisors in a PhD graduate programme influences educational success. We thus ran a cluster analysis to group the departments according to the total number of professors and teaching personnel.

A six-value fuzzy set reflects the structure of our sample best. The departments are considered 'fully in', when their teaching staff exceeds 50 people. They are assigned a membership score of 0.8 (mostly but not fully in) when their teaching staff consists of between 50 and 41 persons. A membership score of 0.6 (more or less in) is assigned, when their teaching staff consists of between

40 and 24 people. A membership score of 0.4 (more or less out) indicates a teaching staff between 23 and 13 people. A membership score of 0.2 (mostly but not fully out) is assigned to departments with a staff between 12 and 9 people. Departments that consist out of less than nine people are considered to be ‘fully out’.

Adding the total number of professors and teaching personnel of the departments as an additional resource condition to the fsQCA does not change the result of the test for necessary conditions. Competition remains the sole necessary condition for the outcome variable as indicated in the analysis of necessary conditions in Table 4.9).

To analyse sufficient conditions, we chose a frequency cut-off of 1 and determined a consistency cut-off of 0.81 to compare both the original and the new analysis. This left us with 13 of our 26 cases with an outcome of 1. Logical remainders were excluded. The results demonstrate only a slight increase in both overall and individual consistency scores; the new overall consistency score is 0.853. In contrast to the original solution, the overall fit of the model decreases with the addition of the total number of professors as a resource condition due to the emergence of an additional configuration solution. The new analysis also indicates that success is possible in departments with few professors – a preliminary result in sharp contrast to the recommendations of Drèze and Estevan (2007), who suggest a minimum size for effective departments.

(e) *Total Annual Number of PhD Graduates*
We also considered the total number of PhD students as an additional condition. We collected the annual number of awarded doctoral degrees from the department web pages and confirmed these numbers during the interviews. We subdivided the departments into four clusters.

The departments are assigned a full membership (1.0) when they graduate more than 13 PhD students annually. We coded the departments to be more in than out (0.66) when they graduate between 13 and 6 PhD students annually. When they graduate less than six, but more than four PhD students annually, they are considered to be more out than in (0.33). The departments that graduate less than four PhD students annually are considered to be fully out (0.0). Adding the total annual number of the PhD graduates of the departments as an additional resource condition to the fsQCA does not change the result of the test for necessary conditions. Competition remains the sole necessary condition for the outcome variable as indicated in the analysis of necessary conditions (4.5). To test for sufficient conditions, we chose a frequency cut-off of 1 and determined a consistency cut-off of 0.80. This left us with 13 of the 26 cases with an outcome of 1. Logical remainders were excluded.

This produced an overall fit similar to the original analysis (consistency score: 0.862), with very similar individual consistency scores as in the original analysis. The assumption that a high number of PhD students are a sufficient condition for the successful outcome cannot be maintained.

The analysis demonstrates that a high number of PhD students are sufficient for three configurations but that a low number of students are also sufficient for one configuration. Furthermore, the number of PhD students is not sufficient for the outcome in another cluster of departments.

4.7 Discussion and Conclusion

We analysed the interplay of five different governance dimensions, and the effects of this interplay on the PhD placement in academic institutions. For this purpose, we focused on the following five governance dimensions relevant in steering higher education: competition, managerial self-governance/hierarchy, state regulations, stakeholder guidance, and academic self-governance. Although the US governance regime is widely considered to be the reference governance system to achieve academic success, our results demonstrate that competition is the only necessary condition for successful PhD education, even if four additional clusters of governance dimensions exist. In each of these clusters departments from each governance regime dominate, but in each cluster there are as well departments from different regimes. We conclude that it is not necessary to imitate the governance system of US research institutions in order to produce highly competitive PhD graduates. To improve PhD education, it is necessary to have a governing framework with a high level of competition and to focus on a beneficial configuration of sufficient governance dimensions.

Our analysis sheds new light on several issues in governing higher education. We were able to connect the theoretical statement from Schimank (2007). Schimank stated from a theoretical perspective that there should be more than one system of governance dimensions underlying academic success. We are able to deliver empirical evidence with our sample of 26 economics departments. Drawing on the example of an academically relevant PhD education, we demonstrate that a successful PhD education is not limited to only one regime. Indeed, we found that there are several best governance systems that are able to facilitate a good PhD education and that it is not necessary for departments – at least in economics – to imitate the governing structure of top US research universities. The results support the assumptions of Schimank (2007) and Schneider and Sadowski (2010) that only a certain number of governance clusters should be necessary and/or sufficient to realise a high-level academic research.

Since our sample is limited in numbers, fsQCA is an excellent method to scrutinise the combination of qualitative and quantitative data that comprise our sample. We find that a successful placement of PhD graduates can be realised in departments with a high level of hierarchy, a high level of external stakeholder guidance and a low level of academic self-governance (configuration 2 and 3, Table 4.9). However, success can also be attained in departments with a low level of hierarchy and a high level of academic self-governance (configuration 1, Table 4.9) as well as in departments with a low level of state control, a high level of external stakeholder guidance and a high level of academic self-governance (configuration 4, Table 4.9). According to the paradigm of NPM, the last two clusters shed new light on the discussion of governing higher education and particularly governing a successful PhD education. Most important, competition is a necessary condition of all successful departments. In addition, departments can also be successful with a low level of hierarchy (configuration 1, Table 4.9). Moreover, we found successful departments where the level of hierarchy makes no difference to the outcome (configuration 4, Table 4.9). We see that academic self-governance plays an important part in the governing structure. But whether a high level or a low level of academic self-governance is important, crucially depends on the additional configuration of governance dimensions. Here we can see the advantage of fsQCA to detect equifinal results.

While successful departments can operate under a variety of governance regimes, our results also indicate that one governance configuration explains less successful departments (Table 4.10): low competition, low hierarchy, high state regulation, and low external guidance. The level of academic self-governance is not important here. Twelve out of 13 departments demonstrate this unfortunate governance pattern, at least in relation to educating PhD students for the academic market. Only 1 of 13 departments exhibits an almost contradictory pattern.

When comparing successful and unsuccessful departments, we were able to demonstrate that they differ most in the level of competition and in the level of state regulation. If the former is missing and the latter is there, departments are unsuccessful at placing PhD graduates in strong programmes. This failure indicates the detrimental aspect of low competition and high state regulation in producing highly competitive PhD graduates.

The findings therefore expand the understanding of the effects of governance to the degree that not all governing dimensions are equally important at the same time but that it crucially depends on the concomitant present governance patterns.

Our results further indicate that different levels of resources do not improve our results beyond the explanatory power of governance dimensions, except for the total number of supervisors and the total amount of financial resources. The addition of the former resource condition does not alter the original solution except for slight changes in the fit scores. It is difficult to get reliable data on the departments' financial resources. However, advantage of fsQCA is that it only requires clustered data as input conditions with logical thresholds. Precise amounts are not necessary to produce interpretable results. Our results indicate that the total amount of financial resources does not produce new solution configurations; its addition only improves the fit of the model. In contrast, breaking financial resources down to the individual level leads to several additional governance patterns, as does the adding of the fifth resource condition, publication success. The results become very idiosyncratic and weaken the power of the original solution. Our findings on programme size demonstrate a more detailed picture than findings in earlier studies. The results contradict the central conclusion of Bowen and Rudenstine (1992) that the scale of a programme affects the success of PhD placements. In addition, the recommendations by Drèze and Estevan (2007), who demand a minimum number of 16 +/−4 students for a successful PhD programme in economics departments, is not supported by our results. This highlights the fact that the size of a PhD programme and its success depends mainly on additional governance factors.

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Part II
Changing the Governance of Science Systems and Effects on Research

Chapter 5
Turning Universities into Actors on Quasi-markets: How New Public Management Reforms Affect Academic Research

Jürgen Enders, Barbara M. Kehm, and Uwe Schimank

5.1 Introduction

New Public Management (NPM) reforms of national university systems aim at a twofold transformation. First, universities as organisations are supposed to become corporate actors (de Boer et al. 2007). The strengthening of their hierarchical self-governance, a corresponding weakening of academic self-governance, and deregulation provide universities with strategic actorhood (Meier 2009). Traditionally, the university represented a commons providing collective goods for its members, an arena where its members fought for the distribution of scarce resources, and a buffer to protect academic autonomy from outside interventions. Nowadays, universities are expected to operate as unified actors with rectors and deans as their representatives to the outside world which implies that these leaders are able to formulate common goals of members inside the organisation.

We gratefully acknowledge the support from the German Research Foundation for our joint project on shifts in governance and academic research that we undertook in collaboration with our colleagues Dr. Harry de Boer, Sandra Bürger, Dr. Ute Lanzendorf, Dr. Liudvika Leišytė, and Nicolas Winterhager. Our insights into the Dutch and English cases have benefited in particular from the analyses provided in Leišytė (2007).

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Second, NPM has deliberately increased the competitive pressure between and within universities. Competition is seen as a proper device to achieve higher efficiency and effectiveness of teaching as well as of research. To put it in a nutshell, scarce financial resources, especially basic funds, shall be redistributed to high performers, while the work of average and low performers shall be rationalised as much as possible. This goal of NPM reforms is often superficially dubbed as "more market!" but has in fact been pursued mainly by the establishment of quasi-markets (Le Grand and Bartlett 1993). Universities, instead of facing a multitude of buyers with a corresponding multitude of preferences, are confronted with a few standardised criteria by which their performance in research and teaching is measured. These criteria are used for performance-based funding decisions frequently supported by evaluations whose results show how a university as a whole, or its disciplines or study programmes can be ranked or rated with respect to their overall quantity and quality of output. The evaluations determine the amount of funding the university will receive. At the same time, governments have reallocated a part of their direct university funding to research councils and targeted research programmes fostering competition among academic units for research grants.

NPM-inspired reforms bring about enforced attention to standardised indicators of measurable quantities and qualities (Paradeise et al. 2009) such as the amount of third-party funding, the number of publications in international refereed journals, or the number of doctorates. We ask in this contribution: Which effects has this massive change of the governance regime of university systems on characteristics of academic research? More specifically, we are interested in the following characteristics:

- Is the quality of research according to scientific criteria affected?
- What are its effects on publication strategies of researchers?
- Is the choice of research topics shaped by these governance changes?
- Does the balance of mainstream and risky research change?
- Is the balance of basic and applied research affected?
- And are there any consequences for the research/teaching nexus?

We explore these questions based on case studies in two scientific fields at universities in four European countries. With the two fields of red biotechnology and medieval history we selected one field from the life sciences expected to represent the new "mode 2 of knowledge production" and one field from the humanities expected to represent the traditional "mode 1 of knowledge production" (Gibbons et al. 1994). The four countries represent a spectrum from a rigorous early adoption of NPM in England on the one hand to Germany as a half-hearted late-comer on the other, with the Netherlands being closer to England and Austria closer to Germany. All in all, we studied 16 research groups, two from each field[1] in each country. In 2004/2005, we conducted our first round of field work. During this period, we analysed shifts in governance in the selected countries and universities, gathered data and documents characterising the selected universities and research groups, and

[1] We aimed at selecting a high-performing research group and an average group.

undertook expert interviews among university managers and the most important academic researchers. In 2008/2009, we conducted a second round of field work on the same sample.

Here we present preliminary results and first impressions. A systematic analysis is still at work. We do, of course, not claim any representativeness of these cases as regards the frequency and strength with which the effects of NPM on research characteristics might occur. The focus of our case study approach lies on the identification of the sometimes complex causal mechanisms that produce certain effects. This approach is a necessary first step towards future studies which can show how widespread particular effects are in these national university systems or, in general, in those systems which underwent NPM reforms during the last decades.

In the following, we provide an overview of our findings and report, for brevity's sake, important differences between countries and fields only. We directly turn to the above-mentioned characteristics of research and ask for each one of them whether and in which respects NPM reforms have made a difference.[2]

5.2 Effects on Research Quality

Practices of quality assessment and assurance have been widely introduced into the university system by now and are increasingly used for funding and allocation decisions. Internal assessments of research performance are typically directed towards either individual researchers or organisational units like faculties, departments, institutes or centres. Indicators are mostly of a quantitative nature (outputs) and accompanied by self-reports. They are frequently based on goal or performance agreements. Such assessments can also be carried out by external agents and then are often directed to the institution as a whole or its organisational units. Expert assessments or peer reviews play an important role in this.

In our study, we focused on the effects of institutional quality management on the research activities of individual researchers and research groups or research units. A variety of consequences are drawn from assessments of research performance reaching from the establishment of institutional research priorities via goal agreements, performance-based contracts and salary components, to the reallocation of research positions and chairs.

Looking at our four countries we find two groups: England and the Netherlands on the one hand and Austria and Germany on the other. England can be characterised as a case of 'hard evaluations', which are strictly coupled with financial consequences and the threat or even practice of reorganisation in the case of low performance. The Netherlands can be characterised as a case of 'soft evaluations' without direct financial consequences, but here also measures of reorganisation are threatened or practiced in the case of low performance.

[2] For a detailed overview of NPM reforms in England, the Netherlands, Austria, and Germany see Kehm and Lanzendorf (2007).

In Germany and Austria, perceptions of the effectiveness of performance contracts or agreements seriously differ between university management on the one hand and the researchers on the other (Kehm and Lanzendorf 2007). As one biotechnology researcher stated: “Contracts are toothless tigers.” It seems that in matters of quality management we are confronted with a rather high degree of symbolic compliance. Management emphasises the seriousness and the consequences of research evaluations and their role for strategic decision-making. The researchers complain about the burden of self-reports and data gathering without any serious consequences at all. This seems to be even more pronounced in Austria than it is in Germany. Most researchers in both countries and from both scientific fields claim that quality management has not influenced their research in any way apart from the fact that an inordinate amount of valuable time is spent on reporting and collecting data. In addition, researchers criticise that there are hardly any consequences, neither positive nor negative ones, based on the outcomes of evaluations. The monitoring of research performance is thus regarded as rather superficial because it does not lead to a tangible redistribution of funds. Often not even a proper feedback is given.

Looking at the development of quality management over time, there was more uncertainty 5 years ago than there is today in all four countries about the criteria that would be applied to measure quality and performance and about the effects of evaluations. As an instrument for quality management, evaluations have spread without, however, achieving progress in terms of their acceptance among researchers. Despite the fact that goal and performance agreements have been based on clearer parameters and criteria, performance-related salary components and budget allocations still play only a minor role in Austria and Germany, often due to the low amount of money available for this. In contrast, in England outcomes of research evaluation exercises are likely to have immediate strong consequences for the funding of units and individuals, their opportunities to buy themselves out of teaching and to build research capacity. In the Netherlands, research assessments have no direct financial effects but inform the university management as well as external sponsors about the competitive standing of a unit and feedback into future funding decisions made for them (Leišytė 2007).

Taking a closer look at the differences between the two disciplines analysed, it turns out that the monetary incentives provided for high performance are irrelevant in biotechnology compared to the level of third-party funding. In medieval history the lack of tangible consequences is more often related to the bridging function of the dean or department head who tends to act as a mediator between performance expectations coming from management and actual performance of individual researchers. In one case, faculties and institutes even have refused to sign the performance contracts that the management wanted to establish.

The difference in perception of how research and research performance is managed can best be explained by taking a closer look at the effects of various management instruments. No researcher claimed that research is not managed at all; however, they tended to negate the effectiveness of instruments and measures that directly target the person. Instead they pointed out that other measures taken by the management are much more effective, and these are mainly activities of restructuring.

Establishing a research profile and deciding about research priorities is done in Austrian universities dominantly by founding research centres outside the traditional department or faculty structure. These centres often follow an interdisciplinary approach, and all institutes and researchers related to the major research theme of a given centre are expected to contribute to it. Refusing to do this or not achieving the expected performance has serious repercussions in terms of funding and institutional recognition. A similar effect can be observed in the research clusters funded through the German Excellence Initiative.

Another instrument is the "thinning out" of research units through a reduction of researcher positions and chairs. In Austria and Germany, this can only be done once they get disposable. Then redefinitions or new denominations are carried out by the management and thus, positions can be shifted to other units or departments. In England and the Netherlands, the weakening of tenure combined with measures for reorganisation allow the institutional management to act more quickly in response to research assessments. In some cases, even high performers may not be protected from reorganisations if they do not fit into strategic priorities of their university.

5.3 Effects on Publication Strategies

The effects of NPM-inspired reforms on researchers' output preferences are tension-ridden and show a clear division between the two subject areas. This is also acknowledged by representatives of university leadership who point to problems in the comparability of disciplines and their preferred publication cultures. This in turn makes a uniform assessment of research output almost impossible and, in the case of one university, has led to the elimination of research output as a criterion for the performance-based allocation of funds.

In biotechnology, the main tension is one between quality and quantity. Researchers claim to have a preference for high-quality publications in international high impact journals – "one paper in a high impact journal in 3 years is better than three papers in journals with a lower reputation" – but also state that they are confronted with contradicting expectations. Increasing competition requires the publication of research results as early as possible; the performance-based allocation of funds which uses publications as an indicator pushes for quantity; and research carried out in cooperation with private sector companies is welcome for its potential for application but might eventually lead to late rather than to early and quick publications.

The requirement that Austrian universities have to deliver a performance report as part of their accountability duties has clearly contributed to more pronounced publication strategies in the research units and among individual researchers. Publication strategies were less pronounced among German biotechnologists ("we publish what we can"), and journals are more often selected according to their thematic fit with the manuscript submitted for publication.

In contrast to biotechnology researchers, medieval historians prefer to produce a monograph after a research project has been finished. However, accountability and reporting duties as well as the pressure for the quantity of output has led to an increased publication of journal articles. Book projects are either "put on the back-burner" or divided into journal articles. In contrast to biotechnology, impact factors hardly play a role. Of course medieval historians state that they are aiming for well reputed journals, but the majority of relevant journals are not included in the citation index. Furthermore, international journals play a less important role because medieval history is frequently local, regional, or national. Regional topics can transgress the borders of current nation states which did not yet exist in medieval times but this fact still does not require publications in international journals as they are known in other disciplines. Thus, the choice of the journal often depends on the topic of the manuscript: "We publish where it fits best."

Researchers of medieval history frequently stated that they feel a growing pressure for more interdisciplinary approaches and for publications upon request. The latter can come from within the scientific community but also from outside. Especially German researchers observed a growing popularity of films, exhibitions and fictional books with medieval topics and they are asked for advice and contributions. This has led to new forms of output targeting a broader and non-academic audience.

5.4 Effects on the Choice of Research Topics

Attempts to influence the problem choice touch upon the core of academic freedom, and are likely not to be welcomed by the researchers themselves. Academic freedom has always been constrained to a certain degree by "material circumstances, historical opportunity, epistemic conviction, and above all, communal doctrine" (Ziman 2000: 204). In recent decades, the growing competition for external research funding, research priority setting by external funders or university management, evaluation criteria set up by academic elites and state bureaucrats, and growing expectations concerning the socio-economic impact of academic research are changes that are meant to change the rules of the academic research game for the shop floor level (Whitley and Gläser 2007; Enders et al. 2009).

Researchers are, however, by no means just passive recipients of such changes in their institutional environment, and our findings suggest that it is indeed not easy to deliberately guide an academic problem choice. Researchers are highly unlikely to compromise their research agenda, unless they are really forced to do so. Their ability to stick to their problem choice depends on their financial resource base, on their performance and reputation, and to some extent on their seniority.

The dominant concerns are to find funding for high-cost projects (biotechnology) or to buy out time from teaching (medieval history). The need for research funding is not a new experience for researchers in biotechnology but it has intensified due to the increasing lack of support from within their university. In contrast, growing needs and expectations as regards external research funding are a newer experience for medievalists. Overall, the resource dependencies from external sponsors as well as their programmes and expectations have grown and influence the process of choosing research problems: ‘no funding, no research’. In consequence, the variety pool of research is likely to decrease even though successful researchers are still able to accommodate funding priorities to their own preferences.

Researchers try to play the game by selecting some topics of their own preference according to the likelihood of funding, and by selling their own ideas in such a way that they fit research programmes at least superficially. They do so mainly by writing project proposals in a strategic way, formulating them according to the exigencies of the funding bodies while following some of their own topics at the same time (see also Leišytė 2007). The dominant response is thus a symbolic compliance with constraints; supported by the ‘Matthew effect’ (Merton 1985) successful research groups or individuals are to a large extent still able to seal some of their priorities off from imposed thematic priorities.

Not all groups are, however, fully successful in this respect. The English case exemplifies compromises in problem choice due to increasing funding problems and lower achievements in the Research Assessment Exercise leading to organisational interventions of an alert university management. In consequence, internal reorganisations lead to thematic reorientations that hope to tune the researchers’ problem choice according to external funding priorities and the rules of the game of the Research Assessment Exercise. English academic researchers have thus faced growing constraints on their choice of research topics that are likely to encourage the homogenisation of research in at least some fields.

Tuning one’s own research topics to the priorities of funding organisations is also nothing new for German and Austrian researchers although admittedly there is a certain element of symbolic compliance involved in such applications as well. Nevertheless, researchers from these two countries particularly emphasised that their choice of topic is increasingly framed by and embedded in larger organisational structures. The trend is towards ever larger research networks, preferably international and interdisciplinary in composition on the one hand and towards integrating research themes into institutional priorities on the other. One of the interviewees stated: “More emphasis is put on the overall presentation and the profile of the individual subjects.” Thus, the choice of topic is not only influenced by the priorities of the funding organisations but also has to take into account its potential contribution to the strategic planning of the university, department or institute.

Our findings indicate that it would be wrong to suggest that research activities cannot be and have not been changed at all. ‘Fundability’ of research is the dominant theme for the researchers mediating the process of setting the academic research agenda. Many researchers, and especially junior researchers, reflect their choices in the light of topical fashions and success rates in funding programmes. The groups’ and individuals’ research agendas are vulnerable mainly due to a lack of resources, lower scores in research performance assessments and an interventionist university management. Thus, we observe a symbolic compliance at work in many cases and self-adaptations and enforced adaptations in some others.

5.5 Effects on the Balance of Mainstream and Risky Research

A related but different issue concerns the effects of NPM-inspired changes in the governance of academic research with respect to the risk taking or risk averseness of academic researchers. At face value, political reforms are obviously accompanied by claims to enhance the innovativeness, responsiveness and effectiveness of the academic research system. Arguments have, however, been put forward that these reforms might be disadvantageous for more open-ended research, non-mainstream research, and specialised research unlikely to be published in what is perceived to be the ‘top’ in the field (see, for example, Lee 2007).

Our findings suggest that academic researchers more and more tend to carry out risk-averse mainstream research to ensure predictable financial inputs and scholarly outputs in an increasingly uncertain and demanding environment. All groups we studied are predominantly involved in what they describe themselves as mainstream research. This means that they follow certain dominant trends in their field as well as the mainstream agendas of external funding bodies. In addition, they anticipate the need to assure a predictable output in order to score in research assessments and to maintain or increase their reputational capital.

Most research units are, however, successfully combining this mainstream work with more risky research lines. Risky research means that the research process and its outcomes are highly unpredictable. Especially highly successful researchers and groups are using different tactics to pursue risky research lines while at the same time conforming to the mainstream. The motivation to pursue risky research, which might not be supported by external funding bodies and might not lead to an output that ticks the boxes of research assessments, is related to the researchers’ serendipity and desire to fuel their reputation building. At the same time, many researchers are convinced that research ultimately dries up and the scientific progress stagnates if there is no longer room for risk-taking.

A certain risk averseness is by no means a new phenomenon. The academic reputation race and the related ‘publish or perish’ culture always fuelled considerations of predictable success as part of the overall research strategy. Epistemic elites defining and controlling mainstream areas of research as well as the access to peer-reviewed funding and publications always played their role as gatekeepers. Research groups perceive, however, growing constraints to pursue risky research. Mostly these constraints refer to an increasing dependency on and competition for external funding. Even funding from the research councils tends to favour mainstream research increasingly framed within priority areas, which are predefined by political actors and epistemic elites. These programmes focus increasingly on predictable, demonstrable outputs and strategic areas. There is little room left for researchers to ‘fail’ and to adjust their research projects, although there are some examples of researchers who manage to be creative in changing their projects as they go along.

Another constraint to pursue risky research is the reduced time to produce research outputs, which is due to the increased competition in the field (especially in biotechnology) and the periodic research evaluations. This was very visible in England due to the Research Assessment Exercise. In other words, researchers regularly have to show research outputs as if they were working on an assembly line.

Given these constraints, the tension between the security of an incrementalist building-up of output and reputation and the eagerness to make a big leap by a major breakthrough is clearly visible in the research units in both fields. Moving into novel areas of research, investing into long-term research with little short-term output becomes an increasingly risky undertaking. Researchers and groups pursue, however, risky research lines in parallel with mainstream lines, partly due to the hope to fuel their reputation in the case of success, to be at the fore-front of the field's competition and to make a major contribution to their research field. The research groups are using multiple strategies to offset these tensions, such as pursuing both mainstream and risky research at the same time, or diversifying their senior and junior staff along the lines of mainstream and risky topics (see also Leišytė 2007). This latter finding is in line with the premise that the position in the academic hierarchy influences the strategies of the researchers. Those at the top of the hierarchy are more likely to take risks and pass some of the risky tasks to the junior researchers (Morris 2004).

5.6 Effects on the Balance of Basic and Applied Research

One of the goals often stated by science-policy makers with regard to NPM reforms was to make science more responsive to needs and demands of other spheres of society, with industry most often referred to but also the health care system, the school system, the military or public administration as some of the other potential users of scientific knowledge. For a long time after World War II, science policy in all Western countries was satisfied with the promise of a diffuse long-term return on investment of academic research in general and research at universities in particular. In the 1970s, this ended abruptly and gave way to a much more specific political insistence on the relevance of academic research for society and economy (Stucke 1993; Braun 1997). Selective priorities to promote technologically promising scientific developments, attempts to forecast scientific breakthroughs with a strong application potential, and a general emphasis on targeted basic research are familiar phenomena by now. Etzkowitz puts forward the idea of a new "triple helix" relationship of science, industry, and government (Etzkowitz and Leydesdorff 1997); Stokes (1997) graphically speaks about a move of academic research into "Pasteur's quadrant", Louis Pasteur being his favourite example for someone who does basic research with clear ideas about the immediate use value of its results for society at large. The – by now – familiar thesis of an emerging "new mode of knowledge production" summarises all these developments (Gibbons et al. 1994).

Against this dramatically changed science policy background which can be found in all four countries, the actual weight of criteria for the determination of what kind of research is done at universities is still basically the same as in the decades before. Especially from the neo-liberal interpretation of NPM in England, one would have expected a strong turn of academic research towards industry. But in fact quite the contrary has happened: a strengthening of traditional scientific quality criteria (Leišytė 2007). In England as well as in other countries, funding programmes with strong application promises have been established, not to forget the Framework Programmes of the EU. However, such programmes were not really new, and there has been no decisive shift of money away from the funding of basic research towards such programmes.

In addition, the criteria and mechanisms of research evaluations work as an overriding counter-force (Whitley and Gläser 2007), even if incentives for application-oriented research would be stronger than they actually are. This is most clearly visible for all evaluations based on peer review. Here the peers – usually highly reputed members of the respective scientific community – uphold scientific quality as the undisputed dominant standard of judgement, whereas relevance to society and economy is of secondary importance, if it is mentioned at all. The same rank order of standards can be seen for indicator-based systems of evaluation. Here, usually publications in international peer-reviewed journals and third-party funds from agencies which rely on peer-reviews for their funding decisions rank highest, and patents or money from industry sometimes do not even count at all. Not even a stronger representation of industrial interests in university boards which by now can be found in many German or Austrian universities is able to challenge this traditional assessment of scientific performance. Recent plans of the British government that the proven economic relevance of research at universities shall become a significant performance indicator show that it was insignificant so far (Metcalf 2010); and it remains to be seen whether the government will be successful this time against the strong opposition of academics.

As a result, the new mission articulated by science policy has been heard in those scientific fields where contacts to users had been established before and among those scientists who already had been application-oriented – but not as something new, just as a reinforcement of something one has already been doing. In other fields, such mission statements of policy-makers or university leaders have had no significant influence on research activities. Statements of that kind might have contributed to a diffuse sense of suspicion among academic researchers against a science policy which – in their eyes – threatens academic autonomy. Red biotechnology is in most parts basic research within a horizon of mid- and long-term application potentials. Scientists from this field explicitly reject, however, ideas to orient their work to other than scientific priorities and do not perceive themselves under such influence. In this context one biotechnologist emphatically stated: "We neither orient our work to potential applications, nor to markets, nor to anything else."

Interestingly, some medieval historians mention a somewhat increased interest of the general public in parts of their work. The humanities in general see themselves to be confronted with the "relevance" question (Meier and Schimank 2004). Although most representatives of these fields deny narrow utilitarian criteria as legitimate yardsticks for the assessment of their kind of research, they nevertheless feel a responsibility to explain why "esoteric" topics are worth to be studied. One way how they legitimise such work is to put it into a greater perspective of interconnected topics some of which can arouse the curiosity of lay people. Pieces of medieval history which are simply entertaining or can contribute to collective identity-building – for instance, of the inhabitants of a village or town – or help to explain contemporary social and cultural phenomena such as gender relations are perhaps more frequently pointed out than before, without a marked shift of research work towards such questions.

5.7 Effects on the Research/Teaching Nexus

Our findings in all four countries and both scientific fields show, first of all, that a tight coupling of research and teaching is emphasised as a desirable ideal. Strong proponents of a decoupling of both activities cannot be found among professors anywhere. In this respect, no significant change has occurred as a result of NPM reforms.

What has happened de facto, however, differs from these wishes. The greatest change has taken place in England (Leišytė 2007). As part of NPM reforms, a mechanism of university financing was installed which strongly pushes in the direction of a decoupling of research and teaching. Basic funding for research is allocated according to the ranking of a university's departments in the periodical Research Assessment Exercise. In the beginning, only a small amount of a university's basic funding dedicated to research was allocated according to the outcomes of this exercise. Since 1992, all these funds have been allocated in this way, with the two lowest performance levels getting "no money at all" (Henkel 2000: 115). On the upper performance levels the 5*-departments get about four times as much money as departments on level 4. This shows the intended high concentration of allocated money. As a result, already in 2001 55 % of research-active scientists at British universities worked in departments of the two upper performance levels; it is the declared intention of research policy to increase this share even more.[3] Moreover, the ranking of a department in the RAE has become an important success factor in the acquisition of third-party funds from the research councils.

The aggregate dynamics becoming apparent here can be pinpointed in the formula "Matthew beats Humboldt" (Meier and Schimank 2009). Merton's (1968) well-known Matthew effect, according to which an already strong research performance enhances future chances to improve research conditions and, as a consequence, future performance, brings about a far-reaching release of strong research performers from teaching duties, which are loaded onto low performers who, as a consequence, are deprived of their research capacities. The mechanism which produces this effect consists, first of all, in a separation of the financial flows for teaching and research, and, secondly, in an allocation of finances for research according

[3]Actually, the RAE 2008 was run in a different mode. We describe here the older mode to which all quotations from interviews in the following refer.

to performance, whereas in teaching only quantity – number of students and number of graduates – counts. Accordingly, if the Matthew effect which already works in the communication system of the scientific communities via the allocation of scarce attention to the contributions of its highly reputed members becomes embedded in such a mode of financing, its impact on research conditions is powerfully reinforced.[4]

In the other three countries, by now no effects of this magnitude can be seen. However, there are at least deliberate first steps in such a direction and the change towards a decoupling of the teaching-research nexus has progressed more in the Netherlands than in Austria and Germany. To illustrate this for Germany: The systems of quality assurance and evaluation which are built up now use separate sets of performance indicators for research and teaching. This separation makes different performance levels of individuals, institutes, or departments transparent with respect to both tasks; and this invites policies of government or university leadership which bring about a stronger decoupling. In addition, there are now first formalised procedures to apply for a teaching buy-out within a research proposal or reduced teaching loads offered to new professorships financed by the Excellence Initiative.

In contrast to the Humboldtian ideal shared by a large majority of professors, quite a number of science and higher education policy-makers favour a stronger or sometimes even total decoupling of teaching and research. From their point of view, the decoupling – most visible in England – is not an unforeseen side-effect of the implementation of NPM but an intended outcome. Even if they often still pay lip-service to the Humboldtian ideal, they simply do not want to waste scarce money on low research performers.

5.8 Conclusion: Does Governance Matter?

The scientific, and even more the public debate about NPM and the universities is dominated by a sharp opposition of enthusiastic NPM promoters on one side and, on the other side, its fierce opponents. Whereas NPM promoters are inspired by great hopes how universities will improve their performance in teaching and research, NPM opponents are driven by strong fears about the end of autonomous science in "academic capitalism" (Slaughter and Leslie 1997).

For both camps governance surely matters: NPM is either the bright future, or the decline and fall of universities. A different position is taken by those observers who claim that, at a closer look, governance does not make any difference. Research work, according to this view, is not really affected by organisational and inter-organisational structures and actor constellations which are shaped by NPM reforms. In a similar vein, sociological neo-institutionalism proposes that such governance changes are merely a legitimating new facade behind which the real work continues

[4] Braun (1993: 66–70), referring to Latour and Woolgar (1979), also combines Merton's emphasis on reputation with a look at financial conditions.

as before (Meyer and Rowan 1977). Neo-institutionalist observers would hold that those NPM proponents who rejoice at what they have achieved by the governance changes are victims of a profound illusion. With respect to NPM opponents, neo-institutionalists would either suspect that their laments are strategic moves to make believe that NPM proponents have reached their goals so that they will stop going further. Or lamenting NPM opponents – in a neo-institutionalist account – mistakenly believe that all their colleagues suffer from these reforms, whereas they themselves are lucky guys who are unaffected.

Our view presented here is that governance – contrary to expectations of neo-institutionalism – does matter indeed. Our empirical data do not just refer to vague impressions of researchers how university research in general is affected by NPM but to immediate experiences of NPM in actual research work.

Our study suggests the following hypotheses due to further empirical investigation:

- NPM is likely to strengthen the external steering of research while reducing the academic autonomy of individuals and groups. Funding priorities, institutional priorities, and performance expectations ingrained in research evaluations are levers that impact on academic research agendas and publication strategies.
- External steering of research and a strong gate-keeping by epistemic elites are likely to have nested effects in terms of decreasing the variety pool of academic research. NPM-inspired reforms increase the resource dependencies of academic research as well as the control by epistemic elites leading to a growing risk averseness of academic researchers.
- NPM reforms are likely to encourage increasing productivity as well as short-termism of academic research. A growing competition for resources, external steering of research priorities, and the increasing oversight by university management fuel the spirit of "publish or perish" in the sciences and also spread it into other academic fields. Overall, output will thus increase while it becomes more difficult to build long-term research lines.
- NPM is unlikely to strengthen the relevance and user orientation of academic research. Preferences of academic researchers are intrinsically motivated by the success within the scientific community and are extrinsically enforced by NPM reforms that fuel the academic reputation race. NPM might be accompanied by the rhetoric of relevance and user orientation, while increasing competition and control rely in practice on traditional academic criteria and mechanisms.
- NPM is likely to push towards a decoupling of research and teaching. The separation of financial supports for research and teaching, of organisational units in charge of research and teaching, and of quality assessments for these functions trigger their further differentiation. These levers also prepare the ground for a further concentration of research leading to a differentiation between research-intense and teaching-intense groups and individuals.

With respect to the effects of NPM we thus expect a mixed blessing. Although many of the effects we noted seem to be dysfunctional for a prospering and innovative scientific knowledge production, other effects may turn out to be quite functional sooner or later. Thus, the general message to science-policy makers is no easy one. If our empirical results are corroborated by further studies, we can neither recommend radical NPM-inspired reforms nor a return to the status quo ante. What seems to be the best way of reforming university governance is a careful point-by-point comparison of how the old governance regime worked with the effects of cautious steps in the direction outlined by NPM, accompanied by a preparedness to modify the direction taken.

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Chapter 6
Multilevel Dynamics in Universities in Changing Research Landscapes

Arie Rip and Tembile Kulati

6.1 Introduction

There are concerns about present changes in, and pressures on, research universities. These will differ not just because they involve different ideas and ideals, but also because the world of universities looks different depending on whether one is a researcher in an academic department, a university administrator, or a government official responsible for higher education policy. For example, university spokespersons coming from a traditional research university may claim that the university is under attack, or at least under heavy pressure, especially from government, to be responsive to external needs, often defined as contributing to economic growth – while a policy maker might see this as an obvious and desirable move to counteract an "ivory tower" tradition. The emergence of so-called managerialism in higher education governance can be associated with these pressures, and might be criticised by researchers while university boards are keen to pursue it. A more detached perspective on the situation is that universities are going through another phase of reforms in their evolutionary history, and that the extent to which these changes will have detrimental consequences for the academic enterprise is far from certain.

To understand what is happening, a detached perspective is important. Analytically, we use a conceptualisation where universities are evolving through multi-level dynamics, where the different levels within the university have different types of resources and different stake/claim-holders and interests, and so respond differently to changes in policy and in research landscapes. The question we address

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in this chapter is about changes in research management, seen as outcomes of multi-level dynamics in context.

In a sense, using the term 'research management' could be taken already as bowing to the new managerialism (just as in the 1940s there was criticism of the increasing use of the term 'research' to indicate what scientists/scholars in universities did (Al 1952). This is of course not our intent. To highlight this we will occasionally put the term between quotes, to indicate the descriptive intent, rather than an ideal of managerialism.

We will start with a brief sketch of the evolution of research 'management' in universities, elaborating our multi-level approach at the same time. Basically, university research and its 'management' is located between two poles: the lateral orientation towards disciplines and sometimes also domains of application, which is dominant at the level of researchers and research groups, and the vertical orientation to government policies towards universities and their funding, which is visible at the level of the president and/or board of the university and top level administration. This basic tension in universities was highlighted by Clark (1983), and it will remain.

In the traditional university structure, there was 'management' at a distance at the top level, limited central administration, and ad-hoc decisions about groups, centres and faculties. The middle level of schools and faculties were little more than administrative holding pens of cognate disciplinary groupings. At the bottom, the real life of academic research was lived, facilitated by the university structure but oriented towards the relevant scientific and scholarly communities.[1] Thus, "bottom-heaviness" is a key feature of the traditional university, where the academic professional wields a powerful influence over academic administration and decision-making. The central administration plays more of a conduit role – for governmental policy – rather than a strategic one. In the same vein, the focus is on 'administration', in the sense of documenting and some accounting, rather than on management which would take the specifics of research domains into account.[2]

Changes are visible from the 1960s onwards, with the expansion of higher education and more pro-active government policies. In general, there was a move towards professionalism and in the 1970s also an injection of democratisation. Attempts at research management started in the 1970s, primarily at the level of faculties and departments, to enable better choices to be made. In some countries, the government department responsible for higher education started to look at the overall higher education system in the country and to devise reorganisations. In the Netherlands, for example, in the 1980s, these took the form of redistribution to achieve critical mass (in education) and more coherence in research through so-called conditional financing. The latter was implemented mainly on paper (Blume

[1] Thus, scientists (and physicists emphatically) could see their chairs or groups as temporary settlements of an international scientific community (cf. Rip 1985).

[2] This heritage is visible in how present-day attempts at the top to be more strategic, in terms of performance management and responsiveness to external needs, still rely heavily on documenting of what happens.

and Spaapen 1988), but had longer term effects in creating an affordance for later changes in the direction of working at the level of programmes and centres of research.

By the 2000s, the world of higher education and research appears to look quite differently. We say "appears" because there are also continuities, as well as further ongoing changes. Governments have become more pro-active, but also adhere to the philosophy and practice of New Public Management (NPM) in delegating ways to achieve performance to lower, more operational levels in the system – in our case, to universities and their organisations (Hood and Peters 2004). Performance-linked funding is part of the landscape, and it is often translated into funding models inside the university. Pressures for accountability are exerted and felt. Researchers and research institutions are asked to be excellent as well as relevant (and this is actually possible under the new regime of Strategic Science, as we will discuss below). In this world, presidents and/or boards of universities see their task as one of profiling their university, making it nationally and internationally competitive, and managing their organisation to achieve such goals;[3] often reproducing the NPM approach, with some adaptation to the specifics of the university, in particular the basic tension between a vertical orientation in the organisation, and the lateral orientation of the researchers and research groups at the bottom level.

At this bottom level, changes have occurred as well, now in response to overall changes in modes of knowledge production and their organisation (greater fluidity, and with variety of alliances), the reputational rewards, and funding regimes.[4] Researchers and research groups have become 'research performance units' with their own 'business model' on the relevant markets for strategic research. Between the top and the bottom level in the university, a newly active intermediary layer has emerged with deans of faculties, directors of research institutes, research committees. Particularly with deans, there is a double allegiance: towards the university, and towards the academic professionals in their faculties or schools. The basic tension of universities is felt acutely and is "resolved" in various ad-hoc ways, for example by siding completely with one or the other side of the double allegiance.

What sort of (intra-university) multi-level research management is now visible, and how can we understand how it has come about? This is the theme of our chapter. Our overall approach refers to two types of independent variables: what we called vertical pressure (and affordances), linked to how the university tries to survive and compete in the larger world; and horizontal pressure (and affordance) deriving from changes in the way science is done (in terms of organisation as well as content). Actually, there is an important intervening or mediating variable: the

[3] We use the possessive pronoun "their" on purpose: there is often a sense of identification, and a drive to make "their" university successful. At the intermediate level, deans can identify with the university, while directors of (big) research centres and institutes almost always identify with the research domain(s) the centre/institute works in.

[4] There is a large literature, often referring to the influential notion of a new (second) mode of knowledge production introduced by Gibbons et al. (1994), see Rip (2000) and Hessels and Van Lente (2008). For other attempts at the diagnosis of new modes of knowledge production and regimes, see Rip (2004) and Bonaccorsi (2008).

type of university and its "business model" e.g. based on traditional excellence or on a "niche" (for research groups, this is a contextual variable). We will offer a typology below.

6.2 Observations

What is happening is often captured in an overall diagnosis, like a shift from a facilitatory mode of research management (at the top) to a directive mode of management (at the top) – or at least, attempts to do so, with varying success. One can then raise the implementation question: how successful are these attempts, and what are unintended effects? This is one question to be addressed through a multi-level approach.[5]

The still limited literature tends to focus on research management from above, much less is known about research management "from below": the life of groups and centres trying to survive. One has to distil insights from case studies as published in the social studies of science literature.

For the actual organisation of research management in universities we can build on a few overview studies in the USA and in Commonwealth countries.[6] Central research management offices in the universities surveyed do grant administration, research administration, some legal/ethical oversight, sometimes also liaison/transfer and Intellectual Property (this can be a separate office). Such offices report to higher executive; their staff can be enterprising.

Strategic research management is the responsibility of higher executives themselves. Formal and informal advice is taken, and strategic positioning and strengthening of research enterprise tends to be linked to the overall mission of university (if there is one), or there are attempts at such. There might be attempts at strategic planning, linked to the introduction of initiatives that promote performance monitoring and benchmarking (the strategic goal being to rise in the Shanghai or THES ranking, or just get into these rankings).

Increasingly, national governments call for quality assurance, from UK and Netherlands research assessment exercises to South Africa's Higher Education Quality Council audits, is taken up by the universities in their own strategies and internal management.

While one can study the instruments and their effects as such, our interest in this chapter is in how research management evolves in the three-level system of universities, in their contexts. Universities as strategic actors can organise themselves

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[5] Both Jansen et al. and Enders et al. (this volume) address the implementation question and argue, drawing on respondent's experiences, that "life at the bottom" tends to continue somewhat independently from measures at the top, in the sense that there is adaptation on paper, but they are able to protect their ongoing work from interference (up to a point).

[6] We draw primarily on the studies of the Association of Commonwealth Universities (Association of Commonwealth Universities 2001) which contained a survey of best practice, and on Baker and Wohlpart (1998). This gives a baseline to refer to when considering further changes.

differently (Whitley 2008), but always see themselves as operating in competitive markets, for students, for funding, for excellent academics. In that sense, universities can have a 'business' model. But in such a 'business' model, the university will depend on the work and achievements of the research performing groups and centres, who survive in an evolving research system. This is the other context that has to be taken into account in our analysis, and it is increasingly taken into account by the actors themselves.

Following Rip (2004), we see the research system evolving towards a regime of Strategic Science. Under the earlier regime of Science The Endless Frontier (after the title of the 1945 report by Vannevar Bush to the US President, cf. Bush (1945)) universities and funding agencies are a key part of the system, next to the big public laboratories working on frontiers of nuclear, aerospace, and materials. The reference to "science" and its progress served to justify the relative autonomy of funding agencies and university research. One could write SCIENCE, with capital letters to indicate it has the character of an ideograph (Rip 1997). The reference to SCIENCE provides legitimation, so it is a symbolic resource. And it can be turned into an argument for material support. In that sense, it is an abstract sponsor of research, while a government department responsible for funding research is a concrete sponsor.

Under the protection of the abstract sponsor SCIENCE, a triangular relation (of mutual dependencies and opportunities) developed between scientists and research groups; funding agencies organised according to disciplines and using peer review; and scientific disciplines and their communities. By now, there is pressure on the triangle, for example the calls for relevance and funding agencies setting 'grand challenges' and using extended peer review. The autonomy of science is not glorified anymore, but the triangle is still the world in which research is done.

What is new is the increasing importance of 'strategic research' as a type of research and as a label in science-policy discourse. The definition by Irvine and Martin (1984) continues to be illuminating: Basic research carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognised current or future practical problems. From the early 1980s onwards, strategic research became pervasive, and the alliance forged between forward-looking politicians and science-policy makers on the one hand, and a new elite of scientists promising to contribute to wealth creation and sustainability on the other hand, is now dominating science policy and science funding. Promising high-tech sciences like genomics and nanotechnologies, and climate change research are prime examples. Thus, there are good reasons to speak of a regime of Strategic Science. Recently, it became strongly linked to the turn to excellence.[7] Excellent research is necessary to create the "broad base of knowledge" necessary as a "background to the solution of (…) problems"; one can trace this reasoning in the recent science policy discourse of 'grand challenges' (RCUK 2009).

[7] We noted a worldwide "return to excellence" in the late nineties after the move towards relevance which started in the 1970s (Hackmann and Rip 2000).

One important effect is that there is now a market for strategic research, on which sponsors of research move (to "buy" research projects), research groups and research centres (of excellence and relevance) operate "selling" research projects, and universities as institutions can refer to in positioning themselves (for example when bidding for major support from private and public sponsors) and organising themselves internally.

To study niches and markets for universities in the evolving system, the Resource Dependence Theory (Pfeffer and Salancik 1978) is helpful. It emphasises the general point that organisations are constantly struggling for autonomy and discretion, as they confront resource dependencies, and thus external controls and constraints on their actions. Basing ourselves on this perspective, we looked for business models for research universities in the present ecology of the research system (Kulati 2011). The exact labels we use for the three types of universities are less important than the observation there are indeed different resource-dependency strategies.

1. "Classical elite" universities, which continue their core business and expand on it, are "bottom-heavy" but often with enterprising presidents. Successful examples like MIT, Cambridge (UK), and ETH (Zürich) are widely recognised and referred to as models.
2. "Enterprising" universities, which pursue opportunities strategically and must thus be able to move their research competencies (internal resources) and profile to exploit such opportunities. Many of the universities created in the 1960s and 1970s aspire to such a model, and there are recognised achievements (cf. Clark 1998). What we identify here is not only the move to economy-oriented entrepreneurial activities in universities (cf. McKelvey and Holmén 2010). This is only one area in which universities can be enterprising.
3. "Niche occupying" universities, with a specific mission linked to a dedicated constituency. Agricultural universities (e.g. Wageningen University in the Netherlands) are an example, and they have to move when their constituencies change. There are many further examples, including the increasing number of private universities in Continental Europe.

In our actual study of Dutch and South African universities we could use the typology to select our cases. We also saw an interesting convergence: Classical elite universities expand and end up in a position similar to that of enterprising universities. The internal governance requirements remain different, however.

6.3 Findings

In addition to mapping the overall higher-education landscape in the two countries we studied, we did detailed studies of the multi-level patterns and dynamics in six research universities (cf. Table 6.1). In interpreting our findings we used information about, and understanding of, what was happening in other universities.

Table 6.1 Universities studied as cases of the three types

Type of university	*South Africa*	*Netherlands*
Classical elite	Witwatersrand (a top university with international reputation, risks falling back and is taking measures to restore its performance)	Leiden (a top university with strong international reputation, maintains position and expands)
Enterprising	Stellenbosch (an Afrikaans university, having pursued opportunities for relevance all along)	Twente (mainly technical sciences and engineering, exploring and using opportunities to expand)
Niche occupying	North-West (merger of a black university (University of the North West) and the white Potchefstroom University for Christian Higher Education, each with its own constituency)	Wageningen (an agricultural (+) university, with strong links with public research institutes for agro-research)

In South Africa, New Public Management was in the air, in the reform agenda of the national government and in the views of university managers,[8] but it was not used to develop strategies and management practices. Instead, there was recourse to an organisational reform "repertoire", fed by experiences in universities elsewhere (North-West looked to the Netherlands, Witwatersrand to Australia, Stellenbosch picked up on strategic management).

Substantive steering, the ability of managers to mobilise and deploy resources in order to give effect to the formal authority conferred to them by policy or regulation, is rare. Only in North-West there was a concerted effort to mobilise resources – they started from a low research base and had targeted a limited number of focus areas.[9]

The establishment of research-priority areas was accompanied in all three cases by the formal designation of entities of research excellence and relevance – which are to constitute/drive the research enterprise of the university. However, there was no one-to-one relationship between overall research priorities (which were weak anyway) and the topics of the recognised entities, other than occasional symbolic conformity (up to relabeling). Their recognition as entities is based on their excellence and relevance as such. Most often, they were already able to mobilise local, national and international funding and other support – so there was some resource independence, visible in the occasional assertion of their autonomy vis-à-vis university management. In other words, the "horizontal" dynamics of research groups in relation to scientific fields and domains of application prevail.

[8] It is not really possible to disentangle NPM as an external driver from the use of instruments by top managers that seek to 'modernise' university without attendant ideological trappings, because the understanding of a 'modern' university is predicated on NPM assumptions of efficiency and effectiveness (cf. also Enders et al. this volume).

[9] Its culture of top-down management (from Potchefstroom's Afrikaaner/Calvinist roots) provided the management with space to be interventionist.

Deans (and directors of important research centres) have become more prominent, and deans are encouraged (and sometimes charged) by the top to start pro-active research management. This is delegation, but often without the deans having sufficient discretionary resources and/or sanctions to make a difference. Let alone the fact that loyalty of the dean to his faculty (where s/he is *primus inter pares*) may be more important, so that s/he becomes a spokesperson for the faculty to the top.

Clearly, there are pressures from above and from below. What then happens reflects the specifics of the faculty and the approach of the dean, rather than the implementation of a top-level approach. What also occurs is that the top bypasses deans to interact with heads of research centres directly. If this becomes a regular practice, the level of deans becomes superfluous, at least for research management and research strategy implementation.

In the Netherlands, competition with other universities (nationally, internationally) pushes the boards of universities to become even more strategic, which is often accompanied by attempts to mobilise academics, e.g. by persuasion or by some joint articulation of strategy. Styles of New Public Management will be drawn upon (delegation and performance indicators), but there are also attempts to nurture (Wageningen, Leiden) and exploit strengths that have been achieved already (Twente).

Deans and directors are expected to carry the brunt of these challenges, and do so in different ways. In Leiden, the top level of the university allows variety, while in Twente and Wageningen games and power plays between faculties and with the top level are visible. Twente has gone farthest in making research management at the middle level independent of faculties by having a limited number of recognised (big) research centres with scientific directors at the same management level in the university as the deans (they all sit in the University Management Team).

In all cases, the smaller and larger research centres operate in the markets for strategic research, and can do so (and create relative resource autonomy) also because of the activities of "buyers", especially funding agencies (including the European Union Framework Programmes) in these markets.[10] Contract research tends to be a minor component of their research activities (except in some social science areas).

6.4 Concluding Considerations

While differences in research management for the three types of universities were expected, in our cases they are minor. As we noted already, 'classical elite' universities flexibly expand and become more like 'enterprising' universities, while the latter try to create and maintain a strong core to build upon. There might actually be an "attractor" position (as Complexity Theory phrases it) to which they all converge.

[10] See Rip (2011) for an analysis of such centres of excellence and relevance, and how they might/will "burst the seams" of the modern university.

There is a large variety of 'niche occupying' universities, and they merge into community colleges (in the USA) and other higher-education oriented institutions (up to "indigenous universities"). We limited ourselves to research universities in which the niche would be shaped with reference to scientific fields and domains of application. This explains why we did not find major differences in multi-level research management with the other two types of universities.

There are differences between the national research systems of South Africa and the Netherlands which help shape the evolution of research management in their universities. This is visible in the relations between universities and the national government, but also in the way research groups and centres can mobilise resources.

In South Africa, in spite of attempts at rationalisation (NPM, quality assurance), a patronage culture (under the *apartheid* regime, but it has not disappeared under the present ANC-dominated regime) reigns. Universities try to profit from patronage, while also attempting to become more independent. Thus, resource mobilisation (also internationally) is important at all levels, and research management procedures and practices can be overridden when a big deal can be closed. Small deals by research groups and centres are welcomed as well, of course, and reinforce the links with the top level, bypassing the level of deans.

In the Netherlands, a mediation culture is in place (Van der Meulen and Rip 1998), with lots of formal and informal anticipatory consultations (including dialogue planning between the Ministry of Education and Science and the Association of Universities). Such interactions and consultations are supported by research assessment exercises and other research management approaches, but these do not replace mediation. Most universities are already players at world level, so they don't need to scramble to become visible. They do need to meet challenges, but can be more relaxed about research management.

There are differences, but everywhere we saw more or less enlightened attempts to create a productive research-management approach for/in universities in their present and changing contexts. Such attempts from the top were fractured by established interests, ongoing practices and horizontal dynamics creating some independence for the research groups and centres. The basic tension between the university as an institution with an education as well as a research orientation remains, and some division of labour may emerge because more assertive evaluation of research performance (Enders et al. this volume). In general, the component groups in a university have their own resource dynamics. The relative independence of these component groups used to be accommodated by a facilitation approach from the top. By now, when the top level tries to be more directive, there will be a struggle, or at least a game, between the top level of the university and the component groups.

Thus, it is not just a matter of the university becoming "porous" (de Boer et al. 2002). The modernist vision of the university as a homogeneous and dedicated organisation may have to be replaced by the vision of a heterogeneous university "complex" (Rip 2011). If such a vision is accepted, research management can escape the stranglehold of fit-for-all approaches, and devote itself to substantial challenges. This will not be easy.

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Chapter 7
Consequences of the New Actorhood of German Universities and Research Organisations

Intended and Unintended Effects on Research

Dorothea Jansen, Regina von Görtz, and Richard Heidler

7.1 Introduction

The governance of universities and research organisations in Germany has changed tremendously since 2000. New Public Management instruments such as target agreements, performance-based salaries, and indicator-based performance budgeting at several levels of the higher education system (state level, organisational level and faculty level) have been implemented in practically all German states. Institutional funding of universities decreased significantly and the percentage of competitive third-party research funding rose from 29 % of university research budgets in 1991 to 40 % in 2005 (WR 2008).[1] The so-called Excellence Initiative spurred competition even

[1] In 1995, for every €100 in basic funding another €13.64 in private funding came in, but in 2005 this ratio had shifted to €21.33. From 2000 to 2005, the third-party funding revenues of universities and medical facilities increased by 29.4 %, whereas the basic funding revenues only increased by 6.5 % and thus, taking inflation into account, decreased in real terms. However, the expenditures of the German states for the German Research Foundation increased by 16.5 %. A little less than a third of the third-party funds for universities come from industry (WR 2008). Moreover, the share of the Individual Grants Programme which the German Research Foundation spent next to coordinated grants programmes has decreased also in real terms (2003: 35.1 %; 2006: 31.9 %, cf. WR 2008: Table 7.4, p. 27).

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further by explicitly asking the top and middle management of universities to take a lead in the coordination of proposals in two tenders (2005 and 2010) of research money (phase 1: €1.9 bn. 2006–2012, phase 2: €2.7 bn. 2012–2017). In line with this, university and department/faculty heads have gained in hierarchical power through reforms of the State Higher Education Acts since 2004 and university self-governance has been weakened. As a result, German universities and research organisations have gained a new form of organisational actorhood, which has turned them into more integrated, goal-oriented entities that are deliberately and strategically choosing their own actions and that can thus be held responsible for what they do (Krücken and Meier 2006).

The governance reforms meet a complex science system characterised by a variety of tasks, throughputs and outputs. New mechanisms such as hierarchical self-management and guidance by external stakeholders and intermediaries such as evaluation agencies were established very much in addition to the old governance system of state regulation and academic self-governance. This mixture has given birth to hybrids such as bottom-up initiatives of collective action of some scientific entrepreneurs. The mixed system met the long established system of self-governance of science where ex-post coordination of scientific work had been achieved by competition for reputation and ex-ante collaboration in invisible colleges, as well as by cultural orientations and missions of different research institutions. Figure 7.1 displays the Governance model that underlies our research design. We look into the mixtures of governance mechanisms and their influence on resources and competencies as well as on the performance of research groups at the shop-floor level. We expect – because of the complexity of the science system and the little reflected

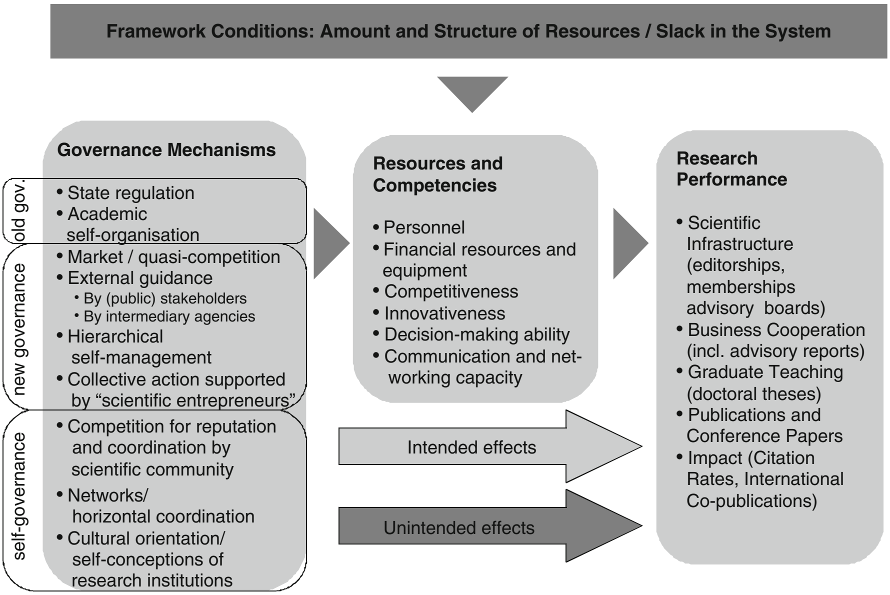

Fig. 7.1 Governance model

mixture of mechanisms – that unforeseen and counterproductive effects are quite likely, e.g. contradictions between the competition for funding and the competition for reputation.

The new governance mechanisms have typically been based on incentive systems designed by the leaders of departments/universities and/or the funding agencies. They request – for example – the acquisition of third-party money, industry collaboration or the interdisciplinarity of networks. As Braun (2007) pointed out, the more complex a system is, the more demanding it will be to steer it. The science system lacks simple and easily measureable outputs, throughputs are important, and the differences between disciplines are large. Detailed knowledge of the vertical and horizontal interactions and interdependencies of the system and of the disciplinary differences of knowledge production processes and network formation are necessary. Since it is difficult for science-policy makers and the heads of universities and research organisations to obtain such detailed knowledge, we expect that the strengthening of the actorhood of research organisations and the rise of competitive pressure will lead not only to intended, but also to unintended and potentially counterproductive effects on research.

Our paper is structured as follows: The next section (Sect. 7.2) introduces the reader to the design and data of our study. Section 7.3 enquires whether and how changes in the governance pattern "in the books" had actually effects on research groups' choices with respect to research lines and research partners or network building. Section 7.4 deals with the complexity and pitfalls of indicator systems, the newly introduced indicator-based performance budgeting, and the dynamics of competition for third-party funding. Section 7.5 looks into the network building and the performance of selected research fields and into the effects of science-policy makers, funding agencies and organisational leaders on collaboration strategies, network building and network structure. Section 7.6 concludes.

7.2 Design and Database of the Study

The study is based on a panel study of 75–77 research groups from astrophysics, nanoscience and economics, representing social science and natural sciences as well as basic and applied research fields for three points in time, 2004, 2006/07 and 2009. The identification of the population of research groups for the three fields in Germany was completed in two steps (for more details c.f. Wald et al. 2007). In a first step, a bibliometric analysis of the Science Citation Index (SCI) and EconLit revealed all researchers that published at least one article in the fields in 2001/02.[2] Since the SCI data are based on individuals, the affiliation of researchers to research groups had to be uncovered with the help of secondary information from directories

[2] The accordant articles were identified by a search strategy developed by the Fraunhofer Institute for Systems and Innovation Research.

and web pages. A research group was defined as the smallest unit within an organisation that works on a more encompassing research programme. The micro-level approach of studying research groups allows assumptions about the way knowledge is produced at the micro level and about the effects of new governance mechanisms. A research group often corresponds to a formal organisational unit, e.g. a chair or a subdivision, but this must not necessarily be the case. In a second step, this group-level list was validated by experts from the different fields. This two-step procedure led to a total population of 223 research groups in nanoscience, 122 in astrophysics and 483 in economics. From the total population thus determined, random samples of 25 research groups for each field (27 for economics) were drawn. A qualitative explorative study based on face-to-face interviews with the leaders of these research groups and complemented by a standardised questionnaire on structure, resources and outputs of the group was conducted in 2004. Based on a qualitative analysis of these interviews (Franke et al. 2006), a standardised questionnaire concerning the factors that influence the choices of research lines and network partners was developed in addition to the questionnaire on structure, resources and outputs of the group. With these the research groups were polled again in 2006/2007 and 2009. Additionally, qualitative semi-structured phone interviews were conducted. With the help of a standardised network generator, ego-centred network data were collected in 2004 and 2006/07 in the personal interviews/ phone interviews; the data included information on attributes and relations of the collaboration partners.

For all three points in time in addition to the output data collected by questionnaires, bibliometric data on number of publications, co-publications and citations were collected from the databases SCI and Econlit/Scopus. As only 60 % of the original sample answered in 2006/2007, the missing 40 % were replaced by a new random sample from the original population. The same procedure was used in 2009. 27 (35 %) of the original sample answered in all panel waves. Forty respondents (51 %) answered only twice (16 in the waves 1 and 2, 20 in the waves 2 and 3, 4 in the waves 1 and 3). Thus, for 77 cases data for at least two of the three time points are available (cf. Table 7.1).

Table 7.2 shows the composition of population and sample in all three panel waves. Both, universities and extra-university institutions are part of the sample. A comparison of the institutional composition of the sample with the population shows that the make-up of the sample is similar to that of the population, and that the different kinds of institutions are represented that the German extra-university research system is divided into. There is a small bias in the underrepresentation of universities and an overrepresentation of extra-university research in astrophysics in the first and in the other direction in the second round. Nanoscience shows a bias in the other direction that increases with time.

Table 7.1 Number of participants and response rates in the three panel waves

	2004	2006				2009		
–	Participants	Contacted	Respondents	Response rate (%)	Response rate 2004 (%)	Contacted	Respondents	Response rate (%)
Astro	25	35	25	71.4	72.0	49	26	53.1
Nano	27	50	25	50.0	59.3	51	25	49.0
Econ	25	52	27	51.9	48.0	56	28	50.0
Total	77	137	77	56.2	59.7	156	79	50.6

Table 7.2 Population and sample

–	–	–	University	Max Planck society	Leibniz association	Helmholtz association	Fraunhofer-Gesellschaft	Other extra-university institutes	Total
Astrophysics	Population	n	67	38	2	5	0	10	122
–		%	54.9	31.1	1.6	4.1	0	8.2	100
–	Sample 2004	n	15	4	2	1	0	3	25
–		%	60.0	16.0	8.0	4.0	0.0	12.0	100
–	Sample 2006/07	n	11	6	2	1	0	5	25
–		%	44.0	24.0	8.0	4.0	0.0	20.0	100
–	Sample 2009	n	13	6	0	0	0	6	25
–		%	52.0	24.0	0.0	0.0	0.0	24.0	100
Nanoscience	Population	n	143	29	6	16	7	22	223
–		%	64.1	13.0	2.7	7.2	3.1	9.8	100
–	Sample 2004	n	19	3	1	1	1	2	27
–		%	70.4	11.1	3.7	3.7	3.7	7.4	100
–	Sample 2006/07	n	18	3	0	1	0	3	25
–		%	72.0	12.0	0.0	4.0	0.0	12.0	100
–	Sample 2009	n	19	3	0	1	0	2	25
–		%	76.0	12.0	0.0	4.0	0.0	8.0	100
Economics	Population	n	465	2	9	0	0	7	483
–		%	96.3	0.4	1.9	0.0	0.0	1.4	100
–	Sample 2004	n	24	1	0	0	0	0	25
–		%	96.0	4.0	0.0	0.0	0.0	0.0	100
–	Sample 2006/07	n	26	0	0	0	0	1	27
–		%	96.3	0.0	0.0	0.0	0.0	3.7	100
–	Sample 2009	n	27	0	0	0	0	1	28
–		%	96.4	0.0	0.0	0.0	0.0	3.6	100

7.3 Governance Changes at the Level of Research Groups

The Tables 7.3, 7.4, 7.5, and 7.6 give evidence that changes in the governance of the German research system at the legal and policy level indeed have effects at the level of research groups and their choices. In the open-ended interviews we conducted in 2004, we found little evidence for effects of the new actorhood of research

Table 7.3 Governance effects on the choice of research lines by fields

–	–	Means (n)	
–	–	Organisations' priorities	External funders' priorities
–	–	*	*
2004	Astro	0.08 (25)	0.20 (25)
–	Nano	0.24 (25)	0.36 (25)
–	Econ	0.00 (25)	0.12 (25)
–	–	**	**
2006/07	Astro	1.04 (25)	0.84 (25)
–	Nano	1.04 (25)	0.88 (25)
–	Econ	0.59 (27)	0.48 (27)
–	–	**	**
2009	Astro	1.00 (22)	0.91 (23)
–	Nano	1.17 (24)	0.84 (25)
–	Econ	0.56 (27)	0.41 (27)

Coding of variables: *1 = mentioned in qualitative interview, content analysis, **2 = applies; 1 = applies partly; 0 = does not apply, standardised questionnaire

Table 7.4 Network strategies and governance effects on choice of network partners by fields

–	–	Means (n)			
–	–	Choice from pool of known partners	Strategic open choice	Organisations' priorities	Funders' priorities
–	–	*	*	*	*
2004	Astro	0.24 (25)	0.68 (25)	0.00 (25)	0.24 (25)
–	Nano	0.28 (25)	0.80 (25)	0.04 (25)	0.20 (25)
–	Econ	0.24 (25)	0.16 (25)	0.08 (25)	0.08 (25)
–	–	**	**	***	***
2006/07	Astro	1.29 (24)	0.52 (23)	0.83 (23)	0.77 (22)
–	Nano	1.08 (24)	0.88 (24)	0.75 (24)	0.96 (23)
–	Econ	0.92 (26)	0.32 (25)	0.59 (27)	0.50 (26)
–	–	**	**	***	***
2009	Astro	1.29 (24)	0.65 (23)	0.68 (25)	0.72 (25)
–	Nano	1.12 (25)	0.84 (25)	0.76 (25)	0.92 (25)
–	Econ	0.84 (25)	0.42 (24)	0.52 (27)	0.48 (27)

Coding of variables: *1 = mentioned in qualitative interview, content analysis; **2 = applies; 1 = applies partly; 0 = does not apply, standardised questionnaire; ***1 = at least one priority ticked in standardised questionnaire

Table 7.5 Governance effects on the choice of research lines by institutional type

–	–	Means (n)	
–	–	Organisations' priorities	External funders' priorities
–	–	*	*
2004	Uni	0.04 (57)	0.25 (57)
–	MPG	0.00 (7)	0.14 (7)
–	Non-university, other	0.55 (11)	0.18 (11)
–	–	**	**
2006/07	Uni	0.73 (55)	0.67 (55)
–	MPG	1.00 (9)	0.78 (9)
–	Non-university, other	1.46 (13)	0.92 ((13)
–	–	**	**
2009	Uni	0.65 ((55)	0.72 (57)
–	MPG	1.44 (9)	0.33 (9)
–	Non-university, other	1.78 (9)	1.00 (9)

Coding of variables: *1 = mentioned in qualitative interview, content analysis, **2 = applies; 1 = applies partly; 0 = does not apply, standardised questionnaire

Table 7.6 Network strategies and governance effects on choice of network partners by institutional type

		Means (n)			
–	–	Choice from pool of known partners	Strategic open choice	Organisations' priorities	Funders' priorities
–	–	*	*	*	*
2004	Uni	0.23 (57)	0.47 (57)	0.05 (57)	0.18 (57)
–	MPG	0.14 (7)	0.86 (7)	0.00 (7)	0.29 (7)
–	Non-university, other	0.45 (11)	0.73 (11)	0.00 (11)	0.09 (11)
–	–	**	**	***	***
2006/07	Uni	1.04 (53)	0.55 (53)	0.65 (54)	0.69 (54)
–	MPG	1.11 (9)	0.88 (8)	0.89 (9)	0.89 (8)
–	Non-university, other	1.33 (12)	0.45 (11)	0.91 (11)	0.80 (11)
–	–	**	**	***	***
2009	Uni	1.02 (55)	0.67 (54)	0.60 (58)	0.60 (58)
–	MPG	1.33 (9)	0.67 (9)	0.67 (9)	1.00 (9)
–	Non-university, other	0.20 (10)	0.44 (9)	0.90 (10)	1.00 (10)

Coding of variables: *1 = mentioned in qualitative interview, content analysis; **2 = applies; 1 = applies partly; 0 = does not apply; ***1 = at least one priority ticked in standardised questionnaire organisations. But the effect of the funders' priorities on choices of research lines is quite substantial. The overall picture changes for 2006/07 and 2009. In particular, the organisations' priorities gain in influence on research subjects, but also the external funders' criteria are taken into account much more often. Overall in 2006 and 2009, the majority of research groups responded that they observe organisational and funders' priorities in the orientation of their research lines. With respect to the choice of research collaboration partners in 2004 there was almost no influence of organisations and only a moderate influence of the funders' criteria. Compared to that, in 2006/07 and 2009 the majority of the respondents reported that they observe criteria for research collaboration set by organisational leaders or funders. Partly the differences between 2004 and 2006/2009 may be due to methodological differences between open-ended interviews and standardised questionnaires. The latter focus more explicitly on the governance issues for doing research that may have got out of attention in the interviews. To control this potential bias we asked whether the relevance of these criteria for the choice of research lines had increased in the last 2 years, which was admitted by a quarter of group leaders for organisational influence and by 29 % of group leaders for the influence of funders.

To summarise, we find that after a period of latency governance changes in the German research system led to the increase of influence of the heads of universities and research organisations on choices of research lines and to the establishment of influence on research collaborations at the shop-floor level. Thereby, besides the established role of research funding agencies, the New Actorhood of universities and research organisations led them to adopt a role in steering research. This resulted in an overall rise of dependency on third-party funding (TPF) in the research system.

However, this picture needs further qualification. There are cognitive, technical and social differences between disciplines. These result in differences in needs for technical infrastructure and resources, as well as in processes of knowledge production, paradigmatic openness versus closure, application relevance, growth patterns, and institutional and technical complementarities (c.f. Bonaccorsi in this volume, 2008; Bonaccorsi and Thoma 2007; Whitley 2000). There are large differences between the three research fields under study and between organisational types as you can see in the Tables 7.3, 7.4, 7.5, and 7.6. Natural sciences need large sums of research money and a large technical infrastructure. Thus it can be expected that research leaders from natural science fields more often than social science groups take the criteria of TPF and organisations into account. This pattern can indeed be found with respect to the orientation towards the funders' and the organisations' priorities in Table 7.3 for all time points.[3] It also applies to the astrophysicists' and

[3] The differences between nanoscience and economics in TPF and organisational orientation were tested in an analysis of variance, confirming their significance: 2004 (sig. 0.048; 0.008), 2006 (sig. 0.049; 0.028) 2009 (sig. 0.029; 0.004). The same is true for the comparison of astrophysics and economics in 2006 (sig. 0.058; 0.048) and 2009 (sig. 0.025; 0.061).

the nanoscientists' orientation towards criteria of funders for research collaboration for all time points (Table 7.4), and for the observance of the organisations' priorities in 2006/07 and 2009. Only in 2004 astrophysics does not follow this pattern.[4] We also find a clear disciplinary pattern for network strategies in all time points. Clearly more often than either astrophysicists or economists, nanoscientists follow an open network strategy choosing new and yet unknown partners strategically, while astrophysicists and economists rely more often on a closed network strategy rather than on an open one.[5] Nanoscience as a new science (cf. Bonaccorsi in this volume) follows divergent research lines using multiple materials and measurement approaches. Thus, it needs expertise from many different disciplines, resulting in an open network strategy and a branching out of research lines. This corresponds to a difference in application relevance which is lowest for astrophysics and highest for nanoscience. However, one should not confound the application relevance with an absence of basic research goals which were underlined by more than 90 % of nanoscientists.

Differences in the affection by new governance mechanisms and in institutional types of research organisations partly result from cognitive differences of disciplines and partly stem from path dependencies and the evolution of policy-science approaches in different countries. This is true also for Germany with its mixture of university research and large research organisations, which either function as umbrella organisations with a limited reach on the decisions of their institutes, e.g. the Helmholtz-Association (HGF) or the Leibniz-Association (LG), or as headquarters governing their institutes, e.g. the MPG (Max-Planck-Society) or the FG (Fraunhofer-Gesellschaft). These large institutions cover the whole range of research types, from high-excellence basic research (MPG) over mixtures of basic and application-oriented research (HGF, LG) to applied contract-research (FG).

The German public non-university research sector always enjoyed a higher level of funding compared to universities. This is partly a result of German consensus federalism. The federal state in the early days of the Federals Republic of Germany had an interest to build up competencies and a power base in science policy which then was a domain of the German states. While universities are funded by the respective state, states and the federal state agreed on funding jointly large non-university research institutions (cf. Hohn and Schimank 1990; Schimank 1996; Stucke 1993; also cf. Bonaccorsi in this volume). While in 2007 higher education had an R&D budget of appr. €95,000 per research position, the research institutes belonging to the four large non-university research organisations spent appr. €114,000 per researcher, which means a plus of appr. 20 % (BMBF 2010: Tables 26, 28, 36, 38). Generally, non-university research institutes always were run more flexible and professionally (partly in private legal forms) than universities and faculties.

[4] Organisational priorities were not mentioned at all in the open-ended interviews in astrophysics. Since these were the very first interviews, this may be due to an error in the guidelines or of the interviewer.

[5] Nanoscience significantly differs from astrophysics (2006: sig. 0.121, n=46) and economics (2006: sig. 0.007, n=48; 2009: sig. 0.057, n=48).

On the other hand, hierarchies have always been much stronger there compared to universities. Since usually a non-university institute consists of a limited number of departments and neighbouring disciplines, a consensus-building on research priorities and scientific relevance is rather easy. The identification of researchers with "their" institution is much stronger (particularly with MPG) and more reflected than in universities. Universities are much more diverse, they bundle together many different disciplines and faculties. This makes hierarchical steering difficult. Therefore we expect that an orientation towards organisational priorities is more acceptable and higher for non-university groups than for university groups. This is what is depicted by Table 7.5. Table 7.5 differentiates between university groups, groups from the MPG and other non-university groups. We find significant differences between university groups and non-university groups for 2004 (sig. 0.000, n = 67), 2006 (sig. 0.002, n = 67) and 2009 (sig. 0.000, n = 63) in the orientation towards organisations' priorities. Similar patterns can be found in Table 7.6 for the effect of organisations' priorities on the choice of research partners. Once again, differences between university and non-university groups are significant. With the exception of 2004, the university groups show the lowest effects in all waves, the non-university groups show the highest effects of organisational priorities, and the MPG groups are in the middle. Again the anomaly in 2004 may be due to the methodical differences.

The picture of the second influence mechanism, namely of the priorities of funding agencies, is less clear. For one thing one could expect that non-university groups because of their much better institutional funding depend less on TPF and therefore do not need to acquire additional funds and to observe funders' criteria. This may have been the case in 2004. On the other hand, the non-university public research sector came under reform pressure, too (c.f. BMBF 2009; Heinze and Arnold 2008). The management of the institutes by the umbrella organisations resp. headquarters was tightened by regular evaluations and programme budgets. This resulted in a strengthening of the institute management which more and more encourages the acquisition of third-party funds being an important criterion in evaluations. Thus, the differences between 2004 and the later measurements may reflect a change of the public non-university research sector from a high slack system towards a system under stronger resource pressure. Groups from all non-university institutions, and particularly those with a mixed profile of basic and application-oriented research, increasingly had to take into account the criteria of funders. The MPG-affiliated groups still seem to be a bit special. They enjoy high institutional funding and a high reputation and can afford to select funding options according to their research interests. The interpretation of the results is also difficult because there is an asymmetric distribution of natural and social sciences between the university and the non-university sectors. The groups from astrophysics mostly come from non-university institutes, nanoscience groups in the sample mostly come from universities, economics groups are almost all affiliated to universities. Another factor of influence is the degree of dependence on TPF, which is higher in natural sciences. The pattern shows that, in general, university groups (in the majority economists and nanoscientists) less often orient their research lines towards funders' priorities than non-university research groups do. This may well be a result of a less hierarchical management and fewer steering incentives in university groups than in non-university research groups.

Summing up, we find strong evidence that the NPM reforms of the German research system increasingly take a substantial influence on the decisions of research groups concerning choices of projects, research lines and network building, and choices of research partners. As described in the introduction, the NPM-steering philosophy strongly focuses on the creation of competition and competitive actors. Research funding agencies and additional special programmes such as the Excellence Initiative and the Joint Initiative for Research and Innovation established such a competitive environment for universities and non-university institutions. It explicitly addressed the heads of universities, departments and institutes to organise for research programmes and large proposals of research clusters, graduate programmes, and new concepts aiming at creating elite universities. At the same time, institutional funding, particularly for universities, decreased in real terms. The relation of third-party funding and institutional funds of universities (except university hospitals) rose from €19.25 TPF per €100 institutional funds in 1995 to €30.27 per €100 institutional funds in 2005. Taking inflation into account, institutional funds during this period stagnated, while the number of students increased from 1.2 to 1.4 m (Federal Statistical Office 2008/2009, own calculation).[6]

At the micro level of research groups we observe an interaction between the strengthening of organisational influences and of third-party funders' influence with a dynamic building on each others incentives and amplifying their strengths and effects. How these mechanisms work and what are their further effects on intervening throughputs such as graduates, resources, network building and research performance will be analysed in more detail in the Sects. 7.4 and 7.5.

7.4 Performance Indicator Systems, Performance Budgeting and the Dynamics of Third-Party Funding

As described above, the NPM reforms of the science system target the improvement of its efficiency by implementing a stronger output control. Furthermore, the reforms are accompanied by the attempt of attuning research agendas to societal needs, especially so that they contribute to economic growth. This section will point out some empirical observations which show in how far the intended effects are reached and why and where unintended effects occur.

[6] Since some higher education institutions (HEI) later reported corrected data, the figures given in Special series 11, Vol. 4.5 do not coincide with the figures in the ICE on Higher Education Finance for 2004. Since winter term 2002/03, the HEI category "Gesamthochschulen" has been integrated into the category "university".

7.4.1 *Multidimensionality of Research Performance*

Besides the disciplinary differentiation of the science system into different research fields and subfields there is also a differentiation of research groups concerning specific output dimensions (c.f. Fig. 7.1). This division of labour is central to the functioning of the research system as a whole, even if not all outputs are awarded equally by the logic of the system. The production of new knowledge is the fundamental goal of the science system, and as such strongly supported by the intrinsic motivation of the scientists, because of its connection to the reputation system (Merton 1957, 1973; Luhmann 1973). Other more intermediary outputs, like the education of PhD students, which serve as input for others, since young scientists can freely move between different research groups, are awarded much less by the logic of the system. A similar argument can be made for infrastructure outputs like working as a dean, organising conferences or editing journals. Since scientists can freely choose in which areas they engage (Krohn and Küppers 1989), it is probable that they specialise according to their abilities and competencies. Learning effects may then lead to increasing returns in the respective dimensions. Nevertheless, a bias of the systems' logic towards an undersupply of intermediary outputs can be assumed. The empirical analysis of the German research groups in astrophysics, nanoscience and economics substantiate that such specialisations indeed exist. A factor analysis of 12 output indicators and a subsequent cluster analysis of these factors reveal that four main types of research groups can be identified: networkers, graduate teachers, frequently publishing scientists and high impact scientists (see Fig. 7.2, first published in German in Jansen et al. 2007 and in English in Schmoch et al. 2010).

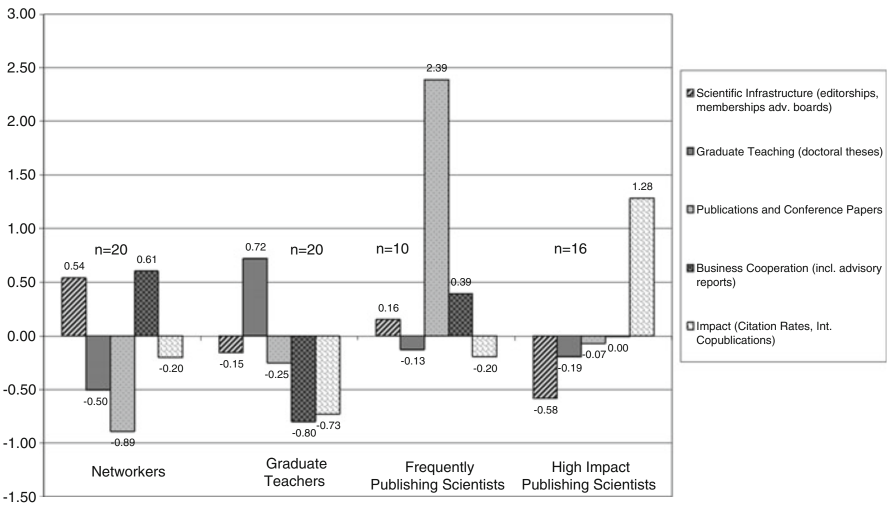

Fig. 7.2 Specialisation of research groups, 2004 data (Jansen et al. 2007: 143; Schmoch et al. 2010: 8)

Table 7.7 Typical activities, 2004 data (Schmoch et al. 2010: 10)

–	Typical activities
Networkers	Organisation of conferences
	Editors of journals or books
	Reviewers for third-party funding
Graduate teachers	Doctoral students play important role in research
	Organise funding for doctoral students
	Organise "Blue Sky" for doctoral students
	Mentoring of doctoral students, career planning
Frequently publishing scientists	Publications and conference papers as important goal of research
	Publications as main goal of external collaborations
	Maximise number of publications per project
	Numbers more important than quality
High impact publishing scientists	Respect themselves as leading scientists in the world
	International orientation/international reference groups
	Research awards; publication in top journals
	Strategic orientation towards positioning in the Web of Science
	Role of principal investigator, coordinators in larger projects

A complementary analysis of this specialisation in the qualitative interviews of the research groups (2004) shows that the scientists are aware of their specialisations (there is a correlation between the quantitative and qualitative typology). The specialisations are reflected in some typical activities which are mentioned by the respective groups (see Table 7.7). A further analysis reveals that there is a high demand for complementary outputs, although they are not as easily exchangeable as monetary values. Unintended effects at the system level can emerge if incentive systems ignore these specialisations or induce one-sided efforts. Since incentive systems like performance-oriented budgeting are spurring research performance, typically by asking for the acquisition of third-party funds (TPF), the danger most probable is an undersupply of intermediary outputs like scientific infrastructure and graduate students. Even if intended effects at the micro level, e.g. an increase in orientation towards the acquisition of third-party funding is achieved, the functional balance at the macro level may suffer. In addition, the efficiency of the overall system may be reduced by losing returns from specialisation, since scientists reflexively specialise into research-performance dimensions and could strategically adapt to the respective incentives.

7.4.2 Indicator-Based Performance Budgeting and Third-Party Funding

A stagnation of institutional funding of universities and research organisations increases researchers' orientation towards TPFs. The share of TPFs in university budgets has been increasing continuously since the 1980s. The rationale behind this development is to induce an increased competition for resources.[7] Of course competition for TPF cannot be an ultimate objective of research, but rather is induced as an instrumental objective. Hence competition for third-party funds may only be regarded as a desirable goal, inasmuch as it contributes positively to the efficiency of the generation of knowledge, which is the conclusive objective. Thus, the intended effect is the increase of efficiency. Unintended effects could emerge if the instrumental and the fundamental goal have a non-monotonous relation, or if they affect negatively other intermediary goals which take effect on the fundamental goal in the long run. The second case was discussed above, the first case is analysed below in more detail for the 77 research groups in the three disciplines (2004 data). The effect of the proportion of time that research groups invest in third-party funded research on their publication output was modelled with a count-data negative-binomial model. The number of researchers in the group and the type of research organisation (university vs. MPG vs. other non-university) served as control variable.[8] The analysis shows that the interrelation between the instrumental goal (third-party funds) and the fundamental goal (research productivity) is indeed curvilinear. The effect of the proportion of third-party funded research on productivity is positive only beneath a certain threshold (see Fig. 7.3, first published in German in Jansen et al. 2007, also Schmoch et al. 2010: 4–7).

This threshold varies between the different disciplines; it is 87 % for nanoscience, 77 % for astrophysics and 45 % for economics.[9] Although these values seem quite high, one must keep in mind that the independent variable is not the monetary proportion of third-party funds in the budget, but the proportion of research time spend for third-party funded projects. A similar analysis with a larger sample (astrophysics n = 34, nanoscience n = 201, economics n = 102) and a fourth field (biotechnology n = 136) corroborates the described curvilinear interrelationship, although a more detailed analysis shows that there can be some exceptions for single funding organisations in some of the fields. Although some intended effects are visible, there is clear evidence for an overall unintended effect being that spending high amounts of research time on TPF projects reduces research performance beyond discipline-specific thresholds (Jansen et al. 2007; Schmoch et al. 2010, see Fig. 7.3).

Despite these problems, in the German research system indicator-based performance-budgeting systems like the *leistungsorientierte Mittelvergabe* (*LoM*) are widely spread. These systems often couple internal institutional funding of

[7] In public media and official science-policy documents the aim of introducing "competition" into the system is often mentioned. This is misleading because a competition for reputation has accompanied the functional differentiation of the system from its beginning (Merton 1957). It is more precise to speak about a "competition for resources".

[8] A statistically more sophisticated model for the same data can be found in Schmoch et al. (2010). It addresses the simultaneity problem which results from the fact that TPF are not totally exogenous in a regression on publications, because although the number of publications is (partly) caused by TPF, the TPF are also caused by publications.

[9] In the model from Schmoch et al. (2010), these values are quite lower with 48.92 % for astrophysics and 67.02 % for nanoscience. For economics research groups the significance of the curvilinear effect vanishes in this model.

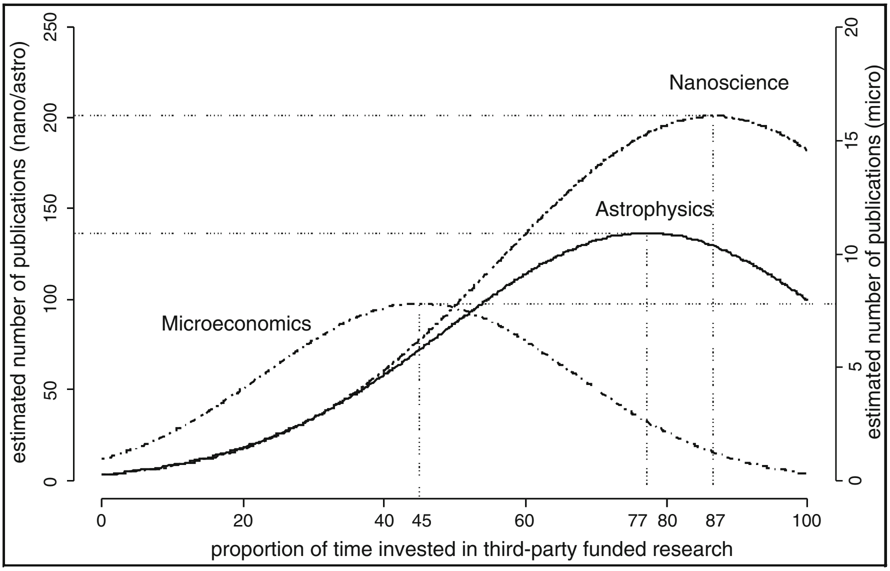

Fig. 7.3 Relation of third-party funds and publications, 2004 data (cf. Jansen et al. 2007: 138)

Table 7.8 Prevalence of indicator-based performance budgeting (LoM) at faculty level, 2006/07 data

LoM implemented at the institution	80.0
Allocation of own resources depending on LoM	50.9
LoM leads to a noticeable change in resources	25.5
Valid cases	55

research to the amount of TPF acquired. The next analysis gives a detailed empirical characterisation of how the LoM is implemented at faculty level (first published in Görtz et al. 2010). It reveals which intended and unintended effects can be expected from this instrument. First of all, the analysis reveals that, despite the high degree of implementation of the LoM at their universities (80 %), much less university research groups report to be affected by it (50.9 %) and even fewer notice a marked reallocation of resources (25.5 %) (Table 7.8). The reason for this is an often purely symbolic implementation of the instrument with only tiny amounts of equipment budget being affected by LoM or a construction of the indicator system in such a way that there is nearly no reallocation. From a perspective of neo-institutionalism this can be interpreted as a large-scale decoupling of an externally visible formal structure from an internal activity structure (Meyer and Rowan 1977). Only some "action" follows a lot of "talk" (Brunsson 1989). Research organisations in this way try to cope with inconsistent internal and external expectations (Hasse and Krücken 2005: 33). In cases of a perceptible reallocation, groups mostly respond with a stronger effort of acquiring TPFs (c.f. Görtz et al. 2010: 17).

Table 7.9 Prevalence of different indicators, 2006/07 data

Third-party funds	86.4
Publications/patents	43.2
Teaching load	45.5
Graduations	52.3
Others, e.g. administrative tasks	13.6
Valid cases	44

Here we observe once again the mutual interdependence between and amplification of strengthened actorhood of universities and competition for TPF. The mechanism behind that is that the amount of TPF is by far the most often used indicator in the LoM. Besides the rationale of the universities to enhance their institutional budget with such measures, the simple measurability surely contributes to the high incidence of this indicator (Table 7.9). The ambiguous effect of the instrumental goal TPF on the fundamental goal research productivity is completely ignored by this indicator. If the fundamental goal "production of new knowledge" is expanded to the system as a whole, a second more basic long-term unintended effect could emerge. As some studies have shown, this leads to a mainstreaming of research (Travis and Collins 1991; Langfeldt 2001; McCullough 1989; Laudel 2006). The argument can be summarised as follows: Groundbreaking research is characterised by serendipity. Unconventional, but potentially innovative research has difficulties in getting both funding and acknowledgement from peers. It is not easily compatible with criteria of third-party funders, who base their decision on previous own work, clear concepts and a research design with established methods and foreseeable results. A strategic adaptation to the assumed criteria of peers in the ex-ante evaluation would lead to mainstreaming of submissions. The quantitative bibliometric analysis shows that the peer-review systems are well suited to identify and sort out the bottom tail of proposals, but have difficulties in an adequate discrimination of the top proposals (Bornmann et al. 2010). Our data reveals for university groups (n = 40, 2006/2007) that research groups have a more risk averse way of generating new research lines, if they are affected by a performance-oriented budgeting system. Ideas for new research lines come more often from the scientific literature (68.3 % with LoM; 33.3 % without LoM) and the group leader (72.7 % with LoM vs. 66.7 % without LoM), whereas research groups which are not affected by LoM generate their ideas rather by group members (36.4 % with LoM; 61.1 % without LoM) or out of discussions with colleagues (36.4 % with LoM 55.6 % without LoM). From this perspective, institutional funding is central for unconventional research to build up a "slack" for risky research. These chances are directly affected by performance-oriented budgeting systems, if they do not remain on a purely symbolic level. Increasing efforts by funding agencies to develop special funding programmes for risky, unconventional research show that this problem is not a purely theoretical one (Heinze 2008).

Besides these unintended effects directly related to the TPF indicator, a second group of unintended effects could emerge out of the oversimplification and unidimensionality of the indicator system. In the majority of the cases, the number of indicators used is low, 50 % of the respective research groups state that only one or two are used. This is corroborated in an international comparative study by Leszczensky et al. (2004: 196). Under the condition of the multidimensionality of research outputs such a system inevitably ignores some of the outputs and runs the risk of leading to an undersupply in these dimensions. This is especially probable, if scientists strategically adapt to these incentives by reducing their efforts and efficiency in other dimensions.

7.5 Networks and Performance in Selected Research Fields: Effects of Science Policy, Funding Agencies and Organisational Actorhood

7.5.1 The Case of Nanoscience as a Mode-2 Field

As was already shown, science-policy makers, organisational leaders, and third-party funders increasingly influence the strategies and choices of research lines and research networks at the micro level. A detailed analysis of the effect of science policy on nanoscience highlights the problems that can occur if policies are based on an insufficient understanding of conditions of knowledge production in specific disciplines. Buzzwords such as "third mission", "Mode 2 of knowledge production", "internationalisation" and "interdisciplinarity" inspire and shape science policies at all levels (Weingart 1997; Beesley 2003). The field of nanoscience is often described as a cardinal "Mode 2" field that is transdisciplinary in nature and oriented towards problem solving (Gibbons et al. 1994[10]; Meyer 2001; Mehta 2002; Jotterand 2006). Also, it is treated as a "Mode 2" field by policy makers (Wald 2007; for an example see BMBF 2004). However, our qualitative interviews show that those working in the field of nanoscience do not consider it to be a "Mode 2" field (Wald 2007). A more detailed analysis of the "Mode 2" characteristics in nanoscience when compared to astrophysics and economics, based on our 2006/07 data, exposed some evidence of Mode-2 characteristics in nanoscience compared to the other two fields (Jansen et al. 2010a). For example, nanoscience is more application-oriented and the resulting knowledge production is more often interdisciplinary. However, basic research remains the main focus of nanoscientists and quality control rests with the academic peers and not with a "community of practitioners" outside of the academic system (cf. Gibbons et al. 1994: 5, 32–33). Compared to the other

[10] Even if Gibbons et al. do not mention the terms "Nanoscience" or "Nanotechnology", which were not yet in popular use at the time, they clearly describe this kind of research: "Instead of purifying natural substances or resorting to complex reactions to obtain those with desired properties, the required materials can now be built up atom by atom, or molecule by molecule, by design, in order to obtain a product with specified properties and possessing certain desired functions." (Gibbons et al. 1994: 45, cf. also p. 19).

two fields, the percentage of industry partners for nanoscience is high. We find this partially to be the result of incentives from organisations and third-party funders. At the same time, nanoscientists have the highest rate of external funding. Thus, nanoscience is far more dependent on third-party funding than the other two fields. This makes it susceptible to changes in funding policies as securing third-party funding is essential. In consequence, it gives policy makers leverage to influence the way in which research groups work in the field of nanoscience.

It is well known that driving basic research fields into Mode-2-type research is unproductive (Mayntz 1998). Also third-party funds from the EU and from industry have a negative effect on the academic performance in nanoscience and biotechnology (Schmoch and Schubert 2009). Following this chain of thought, we analysed whether there is a trade-off between the proportion of science-industry relations of a research group and their scientific productivity or whether research groups can pursue scientific and economic goals simultaneously. We found that having some industry collaborations furthers performance, but having too many industry partners has a negative effect (for details see Jansen et al. 2010a). The results suggest that a basic openness for a small proportion of industry partners allows research groups to exploit these relationships effectively. A small number of industry partners are probably a sign for scientific openness and creativity; but if the dependency on industry partners becomes too high, the scientific productivity suffers. This effect is independent from the proportion of third-party funding, and, thus, not the result of an inflation of the research group through third-party funds. It shows that too many industry partners can be harmful for scientific productivity. These results mentioned above correspond with the findings from the qualitative interviews where nanoscientists reported several problems concerning collaborations with industry partners (Wald 2007). The analysis shows – exemplarily for science-industry relations – that a Mode-2 oriented policy, which treats nanoscience as a Mode-2 field of knowledge production, can have negative effects, at least in the German case.

7.5.2 Disciplinary Differences in Research Networks

Not only collaborations with industry but also research networks in general are considered to further knowledge production and innovation. Collaboration in research is increasingly seen as a factor that positively influences performance in terms of number and impact of publications. This is, for example, reflected in the EU's 7th Framework Programme and in conditions tied to receiving EU funding (Muldur et al. 2006: 102–130; CORDIS 2007). On the national level in Germany, the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) and the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) both have policies promoting collaboration networks (BMBF 2006: 4–5; BMBF 2007: 535–536; DFG 2002: 77; DFG 2007: 17–19). In our data, we find that the formation of research networks is encouraged in all three disciplines by third-party funders as well as by the home organisations (Jansen et al. 2010a; Görtz 2009).

Table 7.10 Regression of network size on sum of publications 1998–2003: Poisson model and negative binomial model (2004 data)

–	Poisson model		NegBin. model	
–	n = 72		n = 72	
Constant	3.4636	0.000	2.1124	0.002
Number of researchers (in full time equivalents)	0.0069	0.000	0.0266	0.043
University affiliation	−1.0649	0.000	−1.0152	0.007
Size of network	0.1435	0.000	0.2838	0.031
Network choices: external funding	0.2810	0.000	0.6518	0.121
(size of network)**2 * field astro	–0.0004	0.606	–0.0055	0.465
(size of network)**2 * field nano	–0.0008	0.319	–0.0069	0.271
(size of network)**2 * field econ	–0.0293	0.000	–0.0219	0.002
Alpha (overdispersion parameter)	–	–	1.343537	0.000
Log-likelihood	–2315.9672	–321.2089		
LR chi2	7312.5	df = 7	60.74	df = 7
Prob > chi2	–	0.0000	–	0.0000
Pseudo R2	0.6122	–	0.0864	–

Corroborating evidence of the positive influence of research networks on performance is mostly based on studies using co-publications as an indicator for research collaboration (e.g. Adams et al. 2005; Frenken et al. 2005; Narin and Whitlow 1990 on international co-publications; Katz and Martin 1997 on the types of collaborations and its measurement by co-publications). The problem of this approach is that only those collaborations that lead to co-publications are investigated; i.e. only relatively successful collaboration in networks (in terms of publication output) can be analysed with this approach. In our ego-network data there is no such bias.

Analysing the relationship between network size and research productivity, we find that the maintenance of research networks is not without costs. Research networks further the performance of research groups; but when research networks become too large, productivity declines. This is – again – due to rising transaction costs in larger networks. Table 7.10 presents the results of a regression analysis based on our 2004 data which uses the sum of publications per group in the time period 1998–2003 as the dependent variable and network size as the independent variable. To measure the potential curvilinear effect of network size, a linear and a quadratic term were included in the equation. The quadratic term was created as a field-specific term to control for the expected differences in economies of networks. As a further effect the orientation of networks choices of the group towards funders' priorities was included. The number of researchers and the affiliation to universities as opposed to extra-university research institutes were controlled for. As can be seen, the linear term is positive and significant at the 5 % level. The quadratic terms all have negative signs (cf. Fig. 7.4). However, the effect is only significant for the field of Economics. The orientation of research groups towards funders' priorities in their network choices has a positive, albeit again not significant effect on performance. The control

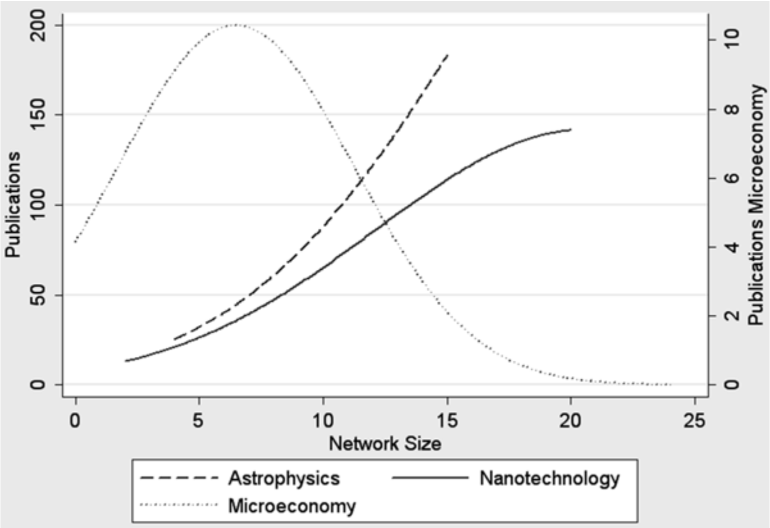

Fig. 7.4 Size of networks and estimated number of publications per subfield (2004 data)

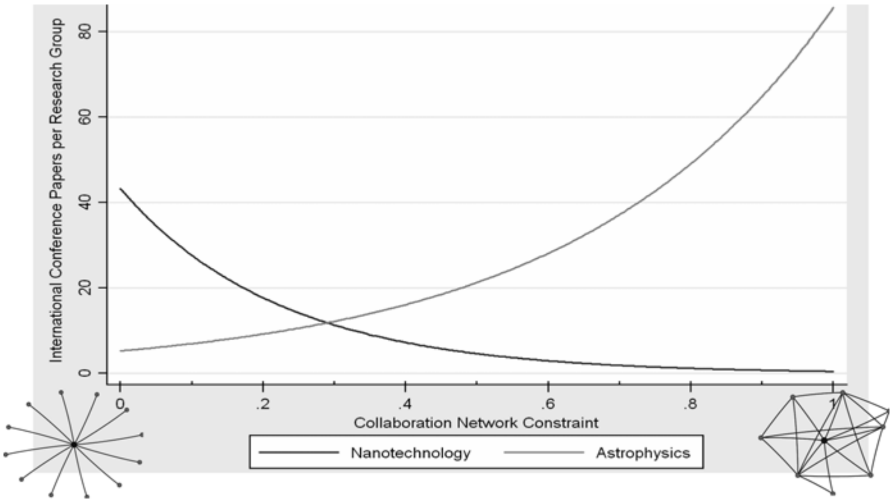

Fig. 7.5 Effect of network structure on scientific performance: predicted values (2004 and 2006/07 data combined), (Jansen et al. 2010b, p. 238)

variables have the expected effects; i.e. both group size and working at an extra-university research institute positively affect the sum of publications.

A more detailed analysis of the network structures in astrophysics and nanoscience revealed that different types of research networks raise the productivity in the two fields: For nanoscientists, heterogeneous open networks are advantageous, while astrophysicists profit from stable, closed networks (Fig. 7.5 first published in Jansen et al. 2010b).

Nanoscience is a new science with an almost exponential growth dynamic and highly divergent research lines. It uses a large variety of materials and requires mostly multi-purpose equipment. Research opportunities in nanoscience are abundant due to the multiplicity of levels of analysis and their interaction. Nanoscientists need ideas on where to look for new materials, how to produce them, on new potential characteristics of the materials and their measurement, etc. Thus they benefit from research networks that do not have redundant ties, i.e. networks that bring together partners that do not already work with each other. Astrophysics, on the other hand, is an old established science growing slowly, following convergent paradigmatic research lines. Research depends on the access to big science institutions and massive equipment. Researchers thus need stable ties to established, highly reputed colleagues to get access to the best telescopes and the best equipment (Jansen et al. 2010b; Görtz and Heidler 2010; Heinze 2010; Heidler et al. 2010).

All in all, researchers are aware of the resources that they seek from their collaboration partners; nanoscientists and astrophysicists differ with regards to the types of resources and skills that they ask from their network partners. Also, there are differences in network strategies between nanoscientists and astrophysicists. While nanoscientists are more likely to choose their collaboration partners in a strategic manner using an open search strategy, astrophysicists prefer to choose their partners from an already established pool of partners. Interestingly, despite these differences in network strategy, overall the network structures do not differ between the two fields with regards to their openness/closedness. Thus, despite "the right" network strategy, some research groups end up with the type of network which is "wrong" for them. We are still in the process of analysing this puzzle. First analyses indicate that differences in research networks can be explained by differences in governance regimes under which research groups operate (Görtz 2009). Sometimes these governance regimes can – unintentionally – push research groups into unproductive networks.

7.6 Discussion and Conclusion

All in all our analyses show a variety of unintended effects of new governance structures on research. These unintended effects become most visible when simple incentive systems are implemented, which do not take into account the complexity of the science system. The multidimensionality of performance profiles of research groups and the various interdependencies within the system are all too often neglected. There seems to be an unawareness of the functionality of slack resources such as endowment of chairs and unconditional institutional funding for, for example, creating niches for "open-ended" research. There are inadequate assumptions about the relationship of the acquisition of third-party funds and performance output, whilst at the same time the time demands of third-party funded projects – which can use up much research time – are neglected. Also neglected are the disciplinary differences in conditions of knowledge production, leading to the belief that simple concepts such as Mode 2 fit well to a reduction of institutional funding. There seems to be a lack of knowledge about both the contingency of network types and disciplinary differences in tasks and optimal networks.

Paradoxically, incentive systems often show the intended effects but only below a specific threshold, or for specific disciplines, or for particular institutional types. If incentives do not take into account the specific conditions of knowledge production, they do not only result in decreasing returns but in negative effects. The necessity of more complexity and flexibility in the use of incentive systems contradicts the "one size fits all" philosophy of NPM and – probably – overburdens science-policy makers as well as university managers.

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Chapter 8
Institutions of Public Science and New Search Regimes

Andrea Bonaccorsi

8.1 Introduction

This chapter deals with the institutions of public science or the relatively permanent or slowly changing features of the way in which science is produced. More specifically, we focus on the way in which public researchers are trained, selected, recruited, funded, managed, and evaluated in the context of country institutions, and the way in which they interact with society at large. Note that this definition is quite restrictive: it neither includes higher education, which is clearly linked to scientific production; nor extends it to the larger (but not completely overlapping) national system of innovation. In addition, by focusing on institutions we call the attention on relatively stable features of national systems, dispensing for more subtle distinctions related to policy, legal or operational issues.

While some institutions, such as the peer-review system, or the openness of publications, are almost universally diffused after the emergence of modern science, there is considerable variability across national systems in other respects. It is this variability that is of interest here. Our main proposition will be that national institutional systems have a long-term performance which depends on their adaptability or flexibility with respect to the challenges created by new scientific fields, or search regimes.

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8.2 Why Is Not Germany a World Leader in Software- and Biotechnology?

It is useful to start our discussion from a case study. Casper et al. (1999) addressed the interesting question whether high-technology industries can prosper in Germany. The authors examine the cases of software- and biotechnology and offer a few stylised facts. To start with, despite large investments and excellent scientific institutions, Germany has consistently failed to emerge as a world leader in information technology, particularly in software technology, and in biotechnology. While the German innovation system has been good in achieving leadership positions in many areas, e.g. from chemistry to electronics and to the automotive industry, its position in software- and biotechnology is not particularly impressive. It is true that consistent federal and regional policies (e.g. the BioRegio Initiative) have significantly improved the situation, but it is also recognised that they have not reversed the trend. As a matter of fact, Germany emerged only in niches characterised by lower levels of investment and less extreme risk, in particular in business software (as opposed to packaged software and systems) and in the technology of bio platforms (as opposed to new drugs). These segments are indeed characterised by a more stable demand, more predictable technological trajectories, less room for disruptive technologies and a lower uncertainty from the regulatory environment.

The authors have contributed to the development of an important framework of a comparative institutional analysis in political economy, labelled "variety of capitalism" (VoC) (Hall and Soskice 2001; Hancké 2009). According to the VoC framework, capitalist societies differ among each other along several dimensions that exhibit considerable resilience and inertia over time. These refer to the way in which firms develop relationships in order to solve coordination problems and are described into five spheres. The first one is how to coordinate bargaining over wages and working conditions, or industrial relations. The sphere of vocational training and education deals with securing a workforce with suitable skills, while solving for the incentive problem of workers about how to invest into training. The third sphere is corporate governance, or the regulation of access to finance and the assurance of returns to investments. The fourth refers to inter-firm relations or the relationships with other companies, notably suppliers and customers. Finally, firms must organise relations with their employees in order to ensure that they have the requisite competencies and cooperate well with others.

Hall and Soskice (2001) offer a detailed comparative analysis of the way in which these relations are institutionalised in various capitalist countries. They come to a broad characterisation which divides countries in liberal market economies (LME) and coordinated market economies (CME). Examples of LME are the United States, Canada, Australia, or the United Kingdom, while Germany, Japan or the Netherlands are cases of CME.

In this line of explanation, CME are better at dealing with incremental innovation rather than with radical innovation (Hall and Soskice 2001: 36–44). The latter involves, in fact, extreme risk and volatility of rates of investment, and significant uncertainty in technology. CME, on the contrary, are based on stable industrial relations, long-term buyer-supplier relations, idiosyncratic investment into skills by workers that are protected from firing, and corporate governance and financial market conditions that make the rapid start up of firms based on disruptive technology and the take-over of companies less likely. The article by Casper et al. (1999) articulates the explanation with respect to Germany, arguing that Germany's institutional framework is not prepared to manage high levels of risk, volatility and industrial turbulence, given that:

- the governance of financial relations emphasises stability, giving a large role to banks;
- corporate governance makes it difficult to fire managers and workers in case of technological or commercial failure, thus making the re-allocation of capital more difficult;
- heavy investments in training on-the-job places value on stability and cumulativeness of skill creation, rather than inter-company worker mobility.

The power of VoC as a general explanation for the innovative performance of nations has been cast in doubt by Taylor (2004) who argues that "the predictions made by varieties of capitalism theory regarding national differences in technological innovation are not supported by empirical data, and that the existing evidence depends heavily on the inclusion of a major outlier, the United States, in the class of liberal market economies" (p. 243). Using patent and publication data, Taylor did not find any systematic relation between VoC categories and long-term innovative performance.

As a matter of fact, the VoC explanation suffers from several drawbacks. *First*, the distinction between radical and incremental innovation is too coarse-grained to have predictive power and to make appeal to scholars of innovation. The literature on innovation has elaborated rich distinctions and taxonomies, which make the broad one used by Hall and Soskice (2001) unsatisfactory. The issue of relations between types of innovation and institutions has also been discussed at some length (Zysman 1994; Amable and Petit 1999; Nelson and Sampat 2001; Nelson 2005). *Second*, any explanation of innovative performance that uses an aggregate measure fails to take into account the model of industrial or sectoral specialisation of countries, and the fact that technological progress is endogenous to the specialisation pattern and persistent over time. Thus, an explanation of the overall innovative performance, without the fine-grained analysis of sectoral patterns of innovation, is incomplete. *Third*, following the dynamic functionalist approach of VoC, one might ask whether it would be possible for larger and/or more complex institutional forms to imitate properties of smaller/more simple forms, obtaining "functional equivalence". As an example, it is true that large German pharmaceutical companies did not have sufficient incentives to engage into high-risk biotechnology-based search for new drugs, as it happened in the venture capital market in the United States. But what about functionally equivalent forms to venture capital, such as corporate venturing (i.e. large firms opening the internal financial market for high-risk/high-return entrepreneurial initiatives) or strategic alliances (i.e. large firms buying "options" on radically new technologies by establishing exclusive agreements with promising startups)? Why did these functionally equivalent solutions fail or were not put in place?

Along this line of criticism, a puzzling question with respect to the VoC classification of countries deals with Northern European countries such as Sweden, Finland, Denmark and the Netherlands. While their capitalist model is certainly outside the LME perimeter, the role of the state pervasive, and the weight of welfare and labour market regulation stringent, all these countries exhibit innovative performances close to, and in some cases even better than, the United States. A related case is Switzerland. How can a VoC model explain such important differences?

We do not find much elaboration along these issues in the literature that followed the introduction of the framework. Interestingly, Hancké et al. (2007) summarising a decade of the debate on VoC, compile an impressive list of criticisms and contributions, along as many as 12 topics, but the authors do not comment on Taylor's critique or on other contributions on innovation. We believe the framework has indeed explanatory power, but it needs several refinements to address the criticisms.

We integrate this comparative institutional perspective with two other perspectives – the analysis of institutions of science, and the notion of search regimes.

8.3 Variety of Capitalism and Institutions of Science

The VoC thesis is correct in establishing a relation between features of the institutional framework and economic performance. However, this relation is intrinsically multi-dimensional and admits a multiple causation and a complex time structure. If it is applied to the explanation of innovative performance, it is under-determined and fails as a general explanation.

We suggest integration between this perspective and two other perspectives. On the one hand, we need a characterisation of institutions of science, as dependent on a higher-level institutional framework, then subject to the VoC type of analysis, but also displaying significant autonomy, for highly specific reasons discussed below. In other words, the relation between the overall institutional framework of capitalism and the innovative activity is mediated by features of the scientific system, which is subject at the same time to highly idiosyncratic, national level pressures, but also to global dynamics. On the other hand, the impact of the overall institutional framework, as discussed in the VoC approach, on innovative performance is highly differentiated according to the specific conditions of technologies and industrial sectors. We suggest that the analysis of search regimes offers a useful characterisation for those innovative performances that depend heavily on the underlying scientific base. It is our contention that the comparative performance of scientific institutional systems, and indirectly of industrial performance in science-based industries, cannot be understood without a careful consideration of differences in the dynamics of the production of knowledge, or search regimes.

8.3.1 Institutions of Science

Following the classical discussion put forward by North (1990: 3), institutions are defined as "the rules of the game in a society, or, more formally, are the humanly devised constraints that shape human interaction". This definition emphasises institutions as binding rules for the action of social actors, who have the property of reducing uncertainty about the behaviour of others, in order to allow credible commitments (Ostrom 1990, 2005). Institutions have also an impact on social cognition and act as focal points for coordination among actors (Furubotn and Richter 2005). A related view, based on the game theory, is that institutions are self-sustaining endogenous rules, or "self-sustaining systems of shared beliefs about a salient way in which the game is repeatedly played" (Aoki 2001).

Institutions tend to be stable over time. An important reason for that is that the different subsystems of society tend to develop complementarities among each other, so that they mutually reinforce and stabilise. Literature has examined several possible complementarities between institutions of contemporary capitalism: between industrial relations, the creation of skills through vocational training and the structure of employment (Streeck 1992; Zysman 1994; Thelen 2004), between corporate governance, training, and innovation patterns (Amable and Petit 1999; Whitley 2007), or between the financial system and employment relations (Hollingsworth and Boyer 1997; Goyer 2007). While complementarities stabilise institutions, they do not prevent changes to occur, due to the imbalance of power, recombinant governance, and institutional entrepreneurship (Morgan et al. 2005; Crouch 2005).

Interestingly, literature has not defined the institutions of science as a relevant subsystem. To be more precise, an earlier formulation of Amable et al. (1997), labelled "social systems of innovation and production", actually included six subsystems: science, technology, industry, education and training, labour markets, and finance. The preliminary discussion identified interesting differences in scientific systems across types of capitalistic systems: for example in market-based economies "the research system is based on competition between researchers and between research institutions", while in the European integration group of countries, including France and Germany, "public basic research is disconnected from new product development within firms, but there are large-scale programmes". It is highly instructive to note that in the more elaborate version (Amable 2009) the subsystem of science disappeared, while some indicators of science have been discussed under the heading of education. Thus we are left with a challenging task of articulating a full-scale notion of institutions of science, and then linking it to other subsystems of society and economy. The recent work of Jansen (2007) goes into this direction, filling a gap in the respective literature. This chapter is a further contribution to this effort.

Let us turn first to the institutions of science. They can be defined as relatively permanent or slowly changing features of the way in which researchers are trained, selected, recruited, funded, managed, and evaluated in the context of national institutions. In most countries, a distinction has to be drawn between scientific research carried out in universities and research organised into public research organisations (PROs). While this distinction is important, both quantitatively and qualitatively, we focus here mainly on academic research, or more largely, on university-based research. Universities are the most diffused and, in most countries, also the largest and most important producers of research.

An important remark is to be made here. The economic analysis of science has discovered a few general institutional rules in science, and it has proposed that they are endogenous self-enforcing rules derived from the solution of a problem of information asymmetry between scientists and society. According to the influential work of David (1991) and Dasgupta and David (1994), the fundamental institution of science is the peer-review system, associated to the open publication of results. This institution is somewhat universal in the sense that it is used in all countries with a modern scientific system. We do not deal with this kind of general institutions here, but rather on other dimensions that still exhibit a considerable variability across countries.

The science institutions can be described according to the following dimensions:

1. Creation of skills for research (doctoral education, post doc)
2. Recruitment and career of researchers
3. Public funding of research
4. Academic governance
5. Institutional complementarities.

In order to characterise these dimensions, we offer a polarised representation describing two extremes, or ideal types, of a possible continuum of intermediate situations. These extremes will be rarely found in pure forms, but summarise the basic features of institutions concretely found in several countries.

One should add two important caveats, however. First, our characterisation captures some of the long-term institutional features of scientific systems. Our main interest in this paper is institutional, i.e. historical and structural. We look for an explanation of the scientific performance of countries, and this explanation has its roots in the history of institutions, as consolidated between the nineteenth century and the period after Second World War, not in the current situation. Therefore the reader should not look for detailed correspondences between our stylised features and the current reality of any given country. Most of them, particularly in Continental European countries, have undergone significant reforms in the past two decades. These reforms have introduced several features that have been historically implemented in systems with a different institutional tradition, thereby reducing the distance between the extremes. Therefore our characterisation, which is deliberately clear-cut, for some countries still refers to the current situation, while for others it better reflects a past situation that reforms are trying to correct.

A clear example is Germany, with which is dealt in the paradigmatic case study of Casper et al. (1999). The institutions of science in this country have undergone deep changes in the 2000s, as witnessed by Kehm and Lanzendorf (2006) and Schimank and Lange (2009). According to Ferlie et al. (2009), Germany has introduced several reforms inspired by the ideas of New Public Management, that is to say, somewhat "imported" from the United Kingdom, in at least the following areas: (i) hardening of soft budgetary constraints (stress on financial control, efficiency and value for money, commodification of activities in policies); (ii) concentration of funds in the highest performing HE institutions; (iii) the Ministry and its agencies attempt to steer the system vertically through setting explicit targets and performance contracts; (iv) growth of performance-related pay per faculty and private sector style human resource management. In particular, the Excellence Initiative has introduced a fierce competition among universities and has spurred the mobility of researchers. Thus the German system has moved away from some of its long-lasting institutional features and is found in-between the two polar types discussed below.

Second, there will be in almost all countries outliers' institutions, i.e. institutions that depart from the institutional norm prevailing in their home country. Thus, while most universities in Italy or France recruit academic staff on a strictly civil servant-type of procedure, based on administrative procedures, there are still universities that implement a fully competitive, totally autonomous recruitment procedure based on seminars, letters of reference and other reputational mechanisms. These are clearly outliers in the institutional framework.

As we will see, an interesting explanatory strategy is to assume that outliers may have a larger impact on small countries, via imitation and isomorphism pressures, than in large countries.

8.3.2 Creation of Skills for Research

Carrying out research is a work that requires an extremely long preparation and high levels of individual motivation. The training system for researchers is different from most other training systems – it cannot be delegated. It is possible to teach mathematics without being an active mathematician or to teach process automation without being an active process engineer. More or less, it is possible to codify the basic content of disciplines, blend them with an adequate degree of practical skills, and train large numbers of students.

This is simply not possible for research because only active researchers can teach graduate students how to do research. To a certain extent, postgraduate education can be formalised along the same lines as undergraduate education, with courses, syllabi and grades. But this is clearly the starting condition – doctoral students wishing to pursue a career in research want to study under the supervision of active, possibly prestigious, senior researchers.

Given this structural condition, there are only two possible options: The supervisor selects, or the student selects. Under the former option, supervisors use cooptation to select students they already know because they have been undergraduate students in the same university or because they are referred to by colleagues in other universities, usually at the national level. Students do not move very much; competition is limited. The continuity between undergraduate and postgraduate education is considered natural and conducive to higher opportunities for learning. Under the latter option, students move, possibly on a world scale, in order to apply for a PhD position at universities they perceive promising for their career. Inevitably, there will be competition for high visibility positions: Universities will compete for the best students; students will compete for the best supervisors.

The way in which doctoral education is organised is at the heart of the debate on the future of European universities. In fact, it is well known that in most Continental countries (such as France, Germany or Italy) doctoral education has been traditionally organised on a local basis, with limited competition between applicants and with supervisors that overlap with tutors in undergraduate education. For example, in the French system, before the reform approved in 1992 was made compulsory in 1999, doctoral grants were directly transferred from the Ministry to the directors of Master programmes, who in general selected the brightest students in their courses (Dahan 2007; Mangematin and Robin 2003; Mangematin 2000). No competition was organised with external applicants. In the German system, the PhD supervisor is still called "father"/"mother", which emphasises a long-term relation. More precisely, there has been a reform implemented in Germany in the past decade. This reform aims at introducing a new way of organising doctoral education, based on formalised courses and more intense competition between applicants. However, the experience is still too young and there is a debate on preliminary, incomplete results of the experiment (Schneider et al. 2010).

More generally, the degree of competition before application, during the first and second year courses, before submission of the thesis proposal and in the defence of the final dissertation are much less severe than in Anglo-Saxon countries. There is not an explicit goal of attracting students from the entire national basin, even less from abroad. Doctoral courses are usually taught in national languages, not in English, and the teaching of courses in English is pursued by a minority of strategy-oriented universities. Consequently, the organisation of doctoral education is compatible with the profile of almost all existing universities, irrespective of their research quality. Small doctoral courses can easily survive alongside mass undergraduate education. On the other hand, it is unlikely that these courses will become attractive for international applicants. Consequently, the mobility of doctoral students will be limited, as recent analyses clearly show (Tremblay 2002; Moguérou 2005a, b). Thus, the limited mobility of PhD students is part of a larger problem of graduate careers in Europe (Schomburg and Teichler 2006; Teichler 2007).

Universities that adopt a strategy in order to attract doctoral students must have dedicated resources, courses in the English language and appropriate facilities. Universities wishing to specialise in postgraduate education in order to become attractive on a global scale must therefore set up dedicated faculty and organisation. According to Zhang and Ehrenberg (2006), in the US system universities granting a doctoral degree have a lower student per staff ratio than universities offering only a baccalaureate. This lower ratio is needed to leave academic staff more time budget for research and doctoral supervision (Graham and Diamond 1997). In turn, this will require a strategic orientation towards postgraduate education, which can be captured by a simple indicator, such as the number of PhD students out of the number of undergraduate students. Using this simple indicator and computing a measure of differentiation between universities in several European countries, Bonaccorsi (2009) showed that only the Netherlands, the United Kingdom and Switzerland seem to exhibit a pattern of differentiation, while Italy, Spain and Portugal do not show any internal differentiation. Compare these features with a description of the US doctoral system:

> Doctoral education, particularly in the sciences, is perhaps the most efficient competitive market in higher education. Each winter a limited number of students with the requisite qualifications apply to those science and engineering departments that would most like to attend and that would be most likely to accept them. The applicants are well informed about the training they seek, and they are highly mobile as well. Each department is a small, autonomous producer, and the departments in each subject area collectively form a national market. Except for pricing, doctoral education approaches the requirements for perfect competition. The key feature of this market is that both applicants and departments vary in quality in ways that are fully understood by both parties: applicants and departments can therefore be ranked according to desirability. Thus, a dual competition takes place - departments seek to attract the most preferred students and students seek places at the most preferred departments in their field. This situation produces a queuing process of allocation. Top departments choose, and are chosen by, the best students; departments in the next tier do the same with the remaining students; and so on down the list. However, this market is highly competitive and the terms of competition fairly delimited. (Geiger 2004: 163–164)

Although with different national trajectories, many Nordic universities (particularly in the Netherlands, Denmark and Sweden) have been following the Anglo-Saxon model, at least in doctoral education. These are cases in which for smaller countries it is easier to adopt features of other systems.

We summarise these differences placing at the two extremes the Continental model, namely the one still largely adopted in large European countries (Germany, France, Spain and Italy), and the Competitive model, adopted in Anglo-Saxon and Scandinavian countries. There will be significant intra-national diversity, insofar as individual institutions might adopt a different model from the national norm. This does not contradict to the broad characterisation we offered at the national level, but rather reinforces it. Table 8.1 summarises the main features of the two stylised models of doctoral education.

It must be underlined that this situation is rapidly changing. Since the late 1990s and early 2000s several countries characterised by the Continental model adopted reforms which aimed at an increasing competition among PhD programmes and the mobility of students. For example, Germany was particularly active in creating graduate schools. As a matter of fact, however, these reforms have been deployed only for one or two full cycles of education of graduate students. Therefore, their impact on the overall population of graduates having a PhD degree is still limited. In addition, we are here discussing the long-term impacts of institutional differences over the current performance of scientific systems. It can also be said that several recent reforms take origin by the recognition of the limits of the Continental model. In this paper we will suggest that these limits are by far larger than currently admitted and reforms should be more rapid and pervasive.

Table 8.1 Characterisation of doctoral education

Continental model	Competitive model
Students come mostly from the university where they received their degree	Fierce competition among students for admission
Professors do not compete for best students but try to have their undergraduate students getting admission	Competition among departments for attracting the best students
Education is largely based on on-the-job training and research work carried out under the supervision of a single professor	Formalised courses and evaluation (Graduate School model). Evaluation of PhD students is carried out by teaching committees, not by individual supervisors or professors
Largely national pool of candidates. No rules for incompatibility between undergraduate and postgraduate education	Increasingly global market. Practical rules for mobility between undergraduate and postgraduate studies
No competition for supervisors	Competition for supervisors (submission of a PhD thesis proposal by students, to be evaluated/accepted by potential supervisors)

While this characterisation admits exceptions of many kinds, it captures a fundamental tension between the two models of training for research in Table 8.1. Under the Continental model, the basic assumption is that universities have all the capabilities needed to train postgraduate students in all required fields. Under this assumption, established teachers can be adequate supervisors, whatever the rate of obsolescence of their scientific background. In the Competitive model, on the contrary, students are encouraged to find the adequate matching between their research interests and potential supervisors everywhere, with no continuity with undergraduate education.

8.3.3 *Recruitment and Career of Researchers*

The second dimension refers to the way in which researchers are recruited and their career is managed.

In all scientific systems recruitment is managed directly by academicians, not delegated to administrative or managerial roles. It is only researchers that can evaluate junior researchers: Recruitment amounts to a cooptation by the scientific community. The procedures for recruitment are highly sensitive to national history and traditions. A large amount of literature has examined this issue in a comparative perspective (Clark 1983; Altbach 1996; Enders 2001). A related stream of literature addresses the issue of recruitment and careers using models from labour economics and the economics of uncertainty and information (Breneman and Youn 1988; Youn 1992; Siow 1995; Ehrenberg 2003, 2004). More recently, Musselin (2005a, b) has offered a detailed comparative analysis of procedures for the recruitment of researchers in Germany, France and the USA across various disciplines.

While recognising the great complexity of recruitment and career decisions, we suggest that national differences can be aligned along a crucial dimension – i.e. the degree of openness of competition for positions. All recruitment systems are intrinsically based on cooptation, but they differ with respect to the extent to which positions are contestable by any entrant, or rather offer some form of advantage to incumbents.

Somewhat in continuity with the above discussion, there is large difference between the Competitive model and a model based on incumbent. In the former, the scientific community (the principal) delegates a small group of evaluators (the agents) to carry out the best possible selection in the interest of the community itself, based on agreed scientific criteria. Since the selection process is not observable by the community, what is expected is that the choice is consistent with a set of quality criteria. Agents place their reputation at risk if they use the discretionary power to make choices that are not in the interest of the academic community. The reputational risk of supporting weak candidates is very large.

In the Incumbent model, which by simplicity is labelled "Mandarin model", the recruitment procedures must follow administrative rules, either at national or local level. Within these rules it is easier to build up coalitions that fight to have their candidates prevailing in the selection process. Agents do not feel accountable to the overall community, but they feel accountable to bureaucratic rules on the formal side and to individual collusive candidates on the substantive side.

The reputational cost for bad choices is not high, insofar as it is expected that agents receive a rent from their position. Quite to the contrary, it is considered that agents that do not exploit their position to build up collusive coalitions will find themselves weaker in the future, jeopardising the recruitment or promotions of their candidates.

The difference between these two extreme models can be better understood as different solutions to a general issue of quality uncertainty. The Competitive model is rooted in the belief that competition and openness are the best mechanisms to discover good quality candidates, while the Mandarin model relies more on the ability of a small group of incumbents. In practical terms, in the former system all candidates have a probability to be selected (roughly) proportional to some (admittedly unobserved) index of quality, while in the latter system there is a sort of lexicographic ordering. In this ordering, the first set of criteria deals with the membership to the incumbent coalition, while quality criteria, although always assumed as crucial, have a second order effect. The notion of in-breeding captures the main dynamic effects. Given the cost of setting up collusive equilibria, it is not rational for candidates to submit their own dossier without having been engaged in extensive preliminary negotiations. Consequently, only those candidates that can enter into at least one coalition will compete. The overall number of candidates will be generally smaller, and above all there will not be foreign candidates, or more generally the share of outliers will be minimal (Table 8.2).

Table 8.2 Characterisation of the recruitment of academicians

Mandarin model	Competitive model
Procedures of recruitment managed at national level and/or at university level but with ministerial guidelines	Large autonomy of departments in recruiting researchers
Formal administrative procedures	Centrality of competitive peer review
Guided peer review	Selection board procedure (=publications + letter of references + interview)
Accountability towards the academic community and the institution, but penalties for reputational losses typically small	Accountability of recruitment decisions towards the academic community based on strong reputational mechanisms
Lexicographic order within the pool of candidates	Large pool of candidates, including foreign candidates
Incumbents have advantage over new entrants	Fierce competition among candidates, no advantage of incumbents

Again, several Continental countries, which have been traditionally associated to the Mandarin model, have introduced deep reforms in recent times. These reforms have introduced many elements of competition and openness that have historically been the backbone of the Competitive model. For example, the practice of letters of references and the internationalization of recruitment are now quite largely used in Germany. Almost all university reforms in countries such as Germany, France, Italy and Spain have addressed the issue of recruitment. The degree to which these reforms have introduced a structural change in the recruitment model, however, is a matter for empirical inquiry, which we leave open for future research.

8.3.4 Public Funding of Research

Governments use a variety of solutions to address the issue of selecting scientific areas as priorities, of deciding the allocation of the research budget, finally of selecting the individual research projects. Governments must delegate these decisions to a variety of institutional agents. In almost all systems the decision is delegated by the government to a minister. Below the minister, however, there are several institutional solutions, ranging from the internalisation of funding decisions in the Ministry of Research (using bureaucratic bodies, expert panels, individual experts, or a combination between these solutions), through their delegation to Research Councils, to their delegation to institutions that combine research funding and research performance.

From a theoretical point of view, funding involves typical problems of principal-agent relations, and then of delegation (Guston 1996; Braun 2003; van der Meulen 2003). Ideally, governments would like to achieve the largest value for unit of expenditure.

Our suggestion is that the architecture of decision-making for funding has an impact on the allocating rules, and ultimately on performance. We focus on the following dimension:

- the degree of internalisation of decisions at ministry level;
- the number of layers of the system;
- the extent of utilisation of peer-review systems;
- the micro-structure of funding, or the ultimate receivers of research funding.

Combining these dimensions, and again pushing them to the extremes, we obtain two ideal types: a Merit-based allocation model, and a Political allocation model.

In the former model, top priority decisions are made at the parliament or government level, usually with an associated decision on the specific budget by area. Then the research budget is delegated to institutions that have no political mandate. They are variously represented by agencies, research councils or other bodies. These are professional institutions with a permanent bureaucracy whose main mission is the implementation of peer-review systems, rather than the allegiance to political decisions. The representation of scientists in governing boards is subject to strict rules for alternation. Explicit rules for the management of conflict of interest are crafted and implemented (Table 8.3).

Compare this to the Political allocation model. Here the ministry of research wants to pursue a significant role downstream in the allocation process. It starts by making decisions on the allocation of the overall research budget by scientific areas. In this process, the ministry makes use of consultative bodies, but because the decision is political rather than professional, rules for representation and for decision making are less formalised and transparent. Second, in several large countries

Table 8.3 Characterisation of the public funding of research

Merit-based allocation model	Political allocation model
Government and parliament play a role in long-term priority-setting ("national priorities")	Ministry of research (at national and regional level, if applicable) wants to exert significant role not only in priority-setting but also in the selection of projects
Government delegates the selection of projects to agencies or research councils with professional staff	Ministry makes the selection of projects through expert panels, which are nominated ad hoc
Systematic Merit-based peer review for allocation of resources to projects	Large public research organisations (PROs) manage a second-level negotiation over priority-setting and internal allocation of resources
Portfolio view of the allocation of resources, with a share allocated to exploratory/risky projects	Allocation follows classical political rules based on equal sharing and consensus
Flexibility in rapid allocation of resources to emerging fields	Rapid growth in resources difficult to implement
Public research funding goes directly to departments and to research teams	Public research funding goes primarily to universities. Separate but not prevalent funding channels go directly to research units

(e.g. France, Italy, Spain, and Germany) a share of the research budget is allocated to large public research organisations (PROs). Here another layer of decision making is found, inasmuch as these institutions must implement an internal allocation of resources. The problem is that even at this level the decisions are rather political than Merit-based. This is due to the fact that several scientific fields compete downstream for resources. It is known from sociological studies that decision makers, faced with problems of priority setting, may refer to non-professional rules that avoid direct judgement, such as standard allocation-rules or formula-based rules (Vilkas 1996; Musselin 2005a). From a political point of view, allocating resources in a differential way across areas (net of obvious differences in cost structures) requires some justification, unless differences are crystallised in institutions. Institutions have the advantage of not requiring recurrent justification. Agency problems, cognitive asymmetries and political justification lead to the widespread adoption of allocative rules based on the (approximately) equal sharing of resources.

This distinction goes down in the architecture of the funding system to the ultimate recipients of research funding. In the Merit-based system, the overwhelming majority of funds are allocated directly to the researchers, or principal investigators, or to research units. These funds are then "portable" in the sense that researchers can move from a university to another and bring their money with them. Universities then compete to retain researchers who are able to attract research funds. The allocative properties of this system are imitated by a few European systems in which the government still funds universities, but on the basis of a separate evaluation of departments. In the UK system, the Research Assessment Exercise evaluates departments each 4 years and the government allocates research funds directly to departments in proportion to the rating. Again, this system places universities in competition to retain the best researchers, although the impact of individuals on university funding is mediated at the level of departments. The presidents of top universities have the mission to recruit the best candidates worldwide. Indeed, Goodall (2008) has found that UK universities that appointed a president who was a recognised scholar gained more in research performance in subsequent years.

In the Political allocation model, there is a significant share of public funding that goes to universities, and not to researchers or research units. Universities then allocate these resources on equal share principles, with modest corrections. In this case, top researchers have little direct power on resources, but must engage in lengthy political struggles and compromises with colleagues.

Admittedly, most research systems have shifted from the block granting of research to a mixed system in which the share of competitive research funding from the government has greatly increased (Geuna 2001; Geuna and Martin 2003; Lepori et al. 2007). The notion of performance funding has also been introduced (Herbst 2009). However, this has only marginally changed the allocation of the real academic power on resources.

This architecture discussed above deeply influences the way in which priorities are set up and the speed and flexibility with which new areas can be funded (Braun 1998; van der Meulen and Rip 1998). Political decision rules favour stability and equality of rates of growth. On the contrary, professional rules may open larger room to differential rates of growth across areas, and also across research projects within areas. In Bonaccorsi (2007) the example of the Italian National Research Council is discussed: There are virtually no examples of a rapid growth of institutes, even in fast moving scientific fields, over several decades. The fact is that it becomes exceedingly difficult for the management of PROs to pursue policies of differential growth, since they are elected, directly or indirectly, by those that are the object of their decisions. On the contrary, agencies and councils may take distance from scientists, and implement political priorities more professionally.

8.3.5 The Governance Model of Universities

The fourth dimension of our characterisation calls into attention the governance of individual universities. The notion of governance may be applied at a high level, such as the overall public research system (Jansen 2007), or at a sub-system level. One of the most debated issues at sub-system level refers to the governance of universities. It has been discussed repeatedly in recent years in the European context because there are claims that European universities suffer from poor governance, resulting in weak autonomy in most important strategic decisions (Aghion et al. 2008).

De Boer et al. (2007, 2008) have examined the governance models of England, Germany, Austria and the Netherlands and have suggested five dimensions of university governance:

(a) regulatory framework from the state (top down authority);
(b) role of stakeholders in guidance through goal setting and advice;
(c) academic self-governance;
(d) managerial self-governance;
(e) competition for scarce resources within and between universities.

Several studies have documented changes in most European countries along their dimensions (a) and (b), i.e. in the relation between the state and universities (from a command model to a steering model), and in the increasing involvement of stakeholders (Henkel and Little 1999; Amaral et al. 2002; Kehm and Lanzendorf 2006; Paradeise et al. 2009). Another dimension in which deep changes have been documented is dimension (d), with the introduction of performance indicators and of New Public Management systems in many countries (Amaral et al. 2003). Most of the authors mentioned above argue that the rate of change is much faster in some countries (e.g. England and the Netherlands) and slower in others (e.g. Germany and France).

However, there is evidence that all these changes have not (marginally) modified the core features of governance of universities in Europe, with the exception of England and of a small number of institutions scattered throughout Europe. The core is that European universities do not really compete for academic staff in a large academic job market, but rather accept recruitment and promotion decisions taken elsewhere by academic communities. Similarly, they do not really compete for students, because they cannot charge student fees with autonomy and have some, but not full autonomy, in defining the educational supply. In some sense, universities have only half part of the autonomy granted by the state: They must exhibit performance along outputs, but they cannot fully determine their inputs (Bonaccorsi and Daraio 2007).

Therefore we offer here a characterisation of governance models which is significantly less articulated than the one suggested by de Boer et al. but captures the main tensions. As usual, it is formulated in an ideal-type shape, with polarisation at the extreme, rather than using a multidimensional characterisation.

As anticipated, a crucial dimension of governance is the balance of power between academic communities, which are organised around scientific disciplines and usually have a national or international scope, and universities. Universities are dual hierarchy organisations in the sense that the administrative chain of command is separated from the academic one. The former is usually much less powerful than the latter (Altbach 1996). Taking the extremes, academic power for recruitment and promotions may be located mainly internally to the individual university, as it happens mainly in the Anglo-Saxon model; or externally, to the national academic community, as it is more often the case in Continental Europe (Clark 1983; Kyvik 2004). In the former case the internal faculty has strong collective power on recruitment and promotions and can implement consistent institutional rules in the long run; in the latter case academic disciplinary circles, mainly at the national level, make decisions autonomously and ask universities to accept. This is an important element of the overall governance of universities (Altbach 2001; Amaral et al. 2002; Del Favero 2003). One important implication of this difference is as follows. Under conditions of dominant academic power, it is almost impossible for an individual university to establish consistent rules for recruitment and promotion over time across all disciplines, in order to build up a reputation. Individual universities are loose coalitions of academicians belonging to disparate academic communities. Incumbents will try to exert their influence for prestige and power by having their students being recruited and promoted, and then will ask their own university to offer positions to candidates whose merit has already been accredited outside. Under these conditions, universities will invariably be characterised by large variability in the scientific quality of researchers. On the contrary, when universities retain a strong voice on recruitment and promotion decisions, which is independent on the opinion of the academic community, they can build up consistent policies across all departments over time.

Somewhat related to this organisational feature, the balance between the chains of command may be designed differently. The so-called Academic collegiate model, typical of European universities, concentrates almost all power in the academic body, usually with processes of shared decision-making. The Presidential model, which is adopted in the United States, creates a strong counterbalance to the academic power, with a powerful Board of Trustees chaired by an authoritative president (Birnbaum 1992; Balderston 1995; Slaughter and Leslie 1997; Bowen and Shapiro 1998; Freeland 2001; Thelin 2004). The president is not responsive to the

Table 8.4 Characterisation of the governance model

Academic collegiate model	Presidential model
Rector elected by all the academic community; no powerful top role separated from the rector	Autonomy of academic community in decisions is preserved but is balanced by a powerful top role ("president") in charge of demonstrating the accountability to stakeholders, shaping the strategy, enlarge the fund raising
Academic collegiate style in most decisions, important role of representative bodies and of collective decision making	When the president has a leadership style, radical changes can be implemented rather quickly
Difficult to achieve consensus on new fields	New scientific or educational fields can be opened and are allowed to grow rapidly in infrastructure and staff
Strategic change is difficult to implement	Strategic change is often the mission of the new president

academic community only, but he also has a large audience of stakeholders and has responsibility on fund raising. One important implication is that presidents are in a strong position to implement strategic change, by changing recruitment rules, or adding new scientific areas, or establishing strategic alliances, or the like. The historical experience has shown that, if the president is also a leader, sometimes a charismatic one, universities may undergo a deep change in relatively short periods (Clark 1998).

In the UK system, in which universities are public but receive money from the government in proportion to their research assessment, and also try to leverage a significant share of funding from private parties, a similar role is played by vice-chancellors. Indeed, Goodall (2008) has discovered that selecting a university leader with a worldwide scientific recognition, as measured by normalised lifetime citations received, increases significantly the research performance in the years after the nomination. This is because a scientific leader may have strong impact on criteria for recruitment and promotions, and may also be active in recruiting worldwide, as opposed to fishing in the domestic pool. Although similar data are not available for, say, Continental European countries, there is little evidence to support such a link.

As usual, we summarised these arguments in Table 8.4 by describing the polar models.

8.3.6 Institutional Complementarities

The previous dimensions have described the internal working of scientific organisations, or the institutional rules for training, recruitment and promotion, and funding of researchers. Along the fifth dimension, we turn the attention to the external side of science, or, in other words, to the broad issue of relations between science and society. However, we do not pursue this issue at large, but rather take a narrow window of observation, that is, the way in which the institutions of science are placed in direct and systematic interaction with non-scientific institutions.

Examples of non-scientific institutions include private companies, government, public agencies, regulatory agencies, hospitals, voluntary associations, patient associations, or other non-profit and civic organisations. From the point of view of social sciences, for non-scientific organisations the interaction with scientific organisations is not mandatory, that is, inscribed in their constitutive mission and evaluated as part of their performance. Companies must produce and sell products, not scientific papers. Hospitals must safe lives, not do experiments. There must be a rationale for such an interaction, one which is mutually beneficial for all parties. The existence and intensity of such interactions, however, depend to a great extent on their overall institutional framework, which is largely dictated by national states and their legal and administrative tradition. By strong institutional complementarity we mean the attitude of the institutional framework to foster complementarity between scientific and non-scientific organisations for the purpose of the production of science, while in countries characterised by weak institutional complementarity we will observe poor interaction.

In defining the notion of institutional complementarity we re-examine an issue that has received huge attention in the last two decades or so, but from a different angle (see for an extended discussion and for references Bonaccorsi 2010). For reasons of simplicity, we restrict the discussion to a specific kind of institutional complementarities, i.e. academia-industry relations, leaving other forms of complementarity for future work.

There are claims that the interactions between scientific and non-scientific institutions have grown largely in the last part of the twentieth century, particularly along the dimension of academia-industry relations. Indicators of such a growth have been identified in the increase of references to academic papers in patents, of citations to academic papers in publications of industry researchers, of academic patents and licensing, of funding and research collaborations between industry and university, of co-authorship of papers between academic and industry researchers, of co-invention of patents, and of academic entrepreneurs. There are two insights from this literature that are relevant to our discussion here. Interestingly, these are also controversial.

The first is that this trend is new. The other is that in the interaction between academia and industry the performance of the European system, taken as a whole, is lagging behind the USA.

The insight that the industry-academia interaction is a relatively new phenomenon is not accepted by several historians of science and technology. Godin (1998) summarises a large and extremely rich literature that has illustrated examples of interaction that go back into history. This literature shows that the origins of industry-academia relations may go deep in the history of industrial capitalism.

The insight that industry-academia interaction is strong in the USA and weak in Europe is another controversial issue. Some studies suggest a more subtle picture. For example, Lissoni et al. (2008) discovered that a significant portion of patents resulting from inventions of academicians in European universities do not follow the formal route of official university patents, but are assigned to a variety of other actors. If the inventive productivity of European scientists were computed by taking into account both official and non-official academic patents, it would not be lower than the one in the USA. In the same line, Conti and Gaule (2009) compared the activities of technology transfer offices (TTO) of European and US universities and concluded that the main difference is not in the quantity of licenses, but in the revenue generated. This is largely due to the lack of professional resources at TTO that come from the managerial career. On the other hand, Mowery et al. (2001) suggested in a critical assessment of the US experience that an increase in licensing may be associated to the deterioration of inventive quality. According to these contributions, therefore, there might be a problem of measurement.

We suggest that a possible distinction lies in the orientation of institutional complementarity with industry: although it may be strong in either France or Germany and the US, in the former countries it is based on large incumbent firms, in the latter there is a significant role for new entrants.

We leave both debates open but call the attention on a few common themes. One is that there are large national differences. In some institutional frameworks, interactions are inhibited or made more costly, for example by rigidity in labour markets and in the structure of careers, or bureaucratic orientation of public administration; while in others they are fostered. To make a concrete example, the complementarity between academia and industry is fostered, if the institutional framework of labour markets facilitates job mobility and if financial markets and corporate governance facilitate entrepreneurial venturing. Another theme is that these differences are usually the result of a long history in which the professional roles of scientists, the institutional missions of universities and the funding schemes of governments came to life. We summarised this discussion in Table 8.5.

8.3.7 Institutions of Science and the Variety of the Capitalism Framework

The dimensions discussed above have a nice, although involuntary, parallel with those suggested in the variety of capitalism literature.

The VoC framework starts with industrial relations, or with the way in which labour processes are coordinated in the workplace and contractual relations are negotiated. This parallels our dimension of recruitment and career of researchers. One important difference is that industrial relations deal with workers being subject to hierarchical supervision, while academicians are professional workers. However, in all systems academicians are also, at least in part, tenured employees of their universities, whatever their governance is (public or private).

The second dimension of the VoC framework, vocational training, which applies to industrial workers, has a parallel into our dimension of doctoral education. Both deal with the institutional processes of skill production and reproduction.

The third dimension of the VoC framework is corporate governance, or the access to funds for investments. For universities there is no capital market, so the access to

Table 8.5 Characterisation of institutional complementarities

Strong institutional complementarity	Weak institutional complementarity
Scientific institutions have strong incentives to the interaction with non-scientific institutions, which is sometimes considered as part of their mission	The scientific system has no in-built institutional incentives to interact systematically with non-scientific institutions (e.g. industry, hospitals…)
Universities consider as their mission the creation of wealth from research, in the form of commercialisation of research and licensing, and allocate to the task dedicated professional roles	Universities accept the notion that research may generate wealth, but organise the commercialisation activity on a non-professional (or poorly developed) base
In the history of the country there is a track record of results obtained from collaboration between scientific and non-scientific organisations	By historical reasons the interaction between scientific and non-scientific organisations does not fit the respective institutional framework
Institutional complementarity with industry is pursued mainly with large incumbent firms	Institutional complementarity with industry is pursued with both large incumbent firms and new entrants (startup companies)
The structure of labour markets makes it easy to move from academia to non-scientific jobs (industry, government)	The structure of labour markets makes it difficult to move from academia to non-scientific jobs (industry, government)
The structure of labour markets makes it easy to establish entrepreneurial ventures that actively involve academicians and to foster their growth	The structure of labour markets makes it difficult for startups originated from research to grow fast

Table 8.6 Correspondence between dimensions in the VoC and in the institutions of science frameworks

Variety of capitalism (Hall and Soskice 2001)	Institutions of science (this paper)
1. Industrial relations (how to coordinate bargaining over wages and working conditions)	Recruitment and career of researchers
2. Vocational training and education (securing a workforce with suitable skills)	Doctoral education
3. Corporate governance (access to finance, assurance on return to investment)	Public funding of research
4. Inter-firm relations (relationships with other companies, notably suppliers and customers)	Institutional complementarity
5. Employees (to ensure that employees have the requisite competencies and cooperate well with others)	Academic governance

finance does not depend on the governance of financial markets but on relations with the government, hence our dimension of public funding of research. Similarly, there are no supply chain and suppliers-customer relations for universities but rather various forms of complementarity with non-scientific organisations.

Finally, the dimension of employees can be related, somewhat loosely, to issues of academic governance. Table 8.6 shows visually this correspondence, following the order of presentation in the VoC literature.

8.4 Institutions of Science and Search Regimes

8.4.1 Integrating the VoC Framework

We are now ready to go back to the original problem: Why is not Germany a world leader in software- and biotechnology? Casper et al. (1999) offered an explanation in terms of characteristics of the German capitalism: stability of employment relations, governance based on long-term financial relations, difficulty to fire workers in case of failure. These characteristics make it difficult to address the extreme volatility of returns of investment that are typical of software- and biotechnology. Interestingly, Germany is specialised in sub-segments of these industries in which the volatility is, contrary to the general industry norm, quite small, e.g. in diagnostic biotech platforms and business software industries.

We find this explanation convincing. However, as already noted, it should be integrated with an explanation based on the institutions of science. This is conceptually needed, because the causality path between institutional features and patterns of innovation posited by the VoC framework is too general and does not stand against a closer scrutiny. We suggest that a mediating role is played by the scientific system, which requires a theoretical development as such. Let us go back to the earlier suggestion of Amable and co-authors (Amable et al. 1997).

There is another compelling reason why we should integrate the framework. The distinction between incremental and radical innovation used by the VoC literature, and the associated notion of volatility of rates of return, although useful, are partial. We need a more fine-grained characterisation, one that might be used across a large variety of innovations.

8.4.2 Search Regimes and Institutions of Science

A useful starting point is the notion of search regimes, as discussed in some of our recent papers (Bonaccorsi 2007, 2008, 2010; Bonaccorsi and Thoma 2007; Bonaccorsi and Vargas 2010). This does not apply to innovation and industrial competitiveness as such but is highly relevant to our discussion for reasons that will be clear soon.

This notion refers to the industrial dynamics of science or to the long-term dynamics of entry, survival and exit of scientific discoveries, and to the associated conditions of the production of scientific knowledge. Three dimensions are identified: the rate of growth, the degree of epistemic diversity, and the forms of complementarity implied in the production of knowledge.

In particular, this notion calls the attention to the new search regimes that can be found in life sciences, materials science (including nano science) and information science. These are young sciences when compared to physics, chemistry and mathematics. They all were born in twentieth century, developed greatly after Second

World War, and exploded in the last quarter of twentieth century. These sciences are subject to a high rate of growth (as measured by the aggregate rate of production of publications and the rate of entry of new fields), to a pattern of increasing epistemic diversity (as measured by the proliferation of new keywords), and to new forms of complementarity (as approximated by various indicators). The complementarity dimension is articulated in three items: cognitive, technical, and institutional. The cognitive dimension captures the complementarity between scientific disciplines (inter-, or multi-, or trans-disciplinarity, according to various authors), while the technical dimension describes the complementarity between researchers and experimental facilities. Finally, as already defined, institutional complementarity refers to the need for scientific institutions to interact and cooperate with non-scientific institutions for their own purposes.

Thus this notion tries to reintroduce in social sciences an accurate appreciation of the dynamics of science, or of the implications of (somewhat) intrinsic epistemic pressures in scientific production. In doing so, it places more emphasis on the context of discovery than on the context of justification, and tries to offer some abstract concepts that are descriptively adequate to capture the dynamics of knowledge across many fields.

8.4.3 Institutions of Science Meet Search Regimes

Why is this notion useful for our discussion of institutions of science? We suggest that different search regimes place challenges to the institutions that must organise the production of knowledge. They originate, from their internal epistemic dynamics, different requirements that have a direct counterpart in the institutions of science. It can be anticipated that the degree to which different institutional systems are able to cope with challenges of search regimes, and particularly of the regimes active in fast moving scientific fields, influences their performance in the long run. We now turn to disentangling these requirements.

8.4.3.1 Rate of Growth

Empirical analysis of science as a production system suggests that there are large differences in the rates of growth of scientific fields. If we accept scientific publications as an indicator of production, there are fields whose rate of growth is 1–2 % per year, and fields that grow 15 % or more for many years in line. Some fields grow exponentially for several years, and then maintain a high rate of linear growth for a long period (Bonaccorsi 2008). While the underlying reasons for these differences are a subject for investigation in itself, it is useful to consider the implications on the institutions of science.

If a field grows slowly, the cognitive distance between successive generations of scholars is kept under control. Established scholars can easily track the development of discoveries and are never found unable to master new results. On the contrary, in fields that grow in a turbulent or disruptive way discoveries are made at a neck-breaking pace and radically new ideas are introduced with high frequency. Under these conditions, established scholars must admit they do not have the cognitive and organisational resources to control seriously the development of the field. This has several important implications.

Let us examine first the implications for the organisation of doctoral studies:

- established faculty may undergo rapid obsolescence of knowledge stock;
- incumbent supervisors for PhD students are not necessarily the best ones;
- talented junior researchers face an extremely high opportunity cost if they cannot work with the best supervisors and/or co-authors;
- conversely, leader scientists need to recruit the best students and researchers worldwide;
- lack of mobility and/or competition is perceived as a serious obstacle.

Thus, institutional systems that favour competition and mobility are better placed to deal with the challenge of rapid or turbulent growth, or, as scientists often say in these fields: "Each day lost is a waste of time".

There is another important implication of the rate of growth on the funding of public research. When fields grow slowly or predictably, their funding needs tend to grow roughly in proportion to the existing stock of researchers. It may be considered that the number of new researchers trained by good scientists per period of time should not change drastically over time. Consequently, a funding system which allocates resources following political rules, on equal shares, is considered acceptable. But what happens if some fields undergo turbulent changes? Their funding requirements will be disproportionate with respect to other slow growth areas. Now an allocation of resources based on equal shares means that rapidly growing scientific fields are forced to grow much less than it would be optimal (whatever this may mean).

8.4.3.2 Degree of Diversity

The second dimension of search regimes is the degree of intra-paradigmatic diversity. As largely discussed in the Kuhnian theory of scientific change, periods of high diversity among scientists tend to characterise either the end of established paradigms or the emergence of new ones. During periods of normal science, there would be a reduction of diversity, insofar as scientists converge on common definitions of the most important problems to be solved, as well as on methods, loci of exploration, experimental settings, techniques, and data. Scientists search for new results that confirm the predictions or explanations of the theory. They converge on experiments, since they share common beliefs on "where" the next discoveries can be found.

Our definition of search regime calls the attention on the possibility that some (but not all!) scientific paradigms have an internal structure that increases diversity over time. In this case scientists converge on the overarching paradigm, but then diverge significantly on local theories, on hypotheses and sub-hypotheses, or on various aspects of the process of discovery. In some extreme cases, each discovery opens the way to a proliferation of new hypotheses which were not initially conceived. In a recent paper, we have analysed diversity in the field of nanoscience and proposed a measure of proliferation based on bipartite graphs on articles and keywords (Bonaccorsi and Vargas 2010). Using a slightly different notion of diversity, Laredo and van den Besselaar (2008) found that chemistry as a whole is a field with low growth and moderate diversity, while sub-fields such as catalysis experienced rapid growth, and the sub-sub-field of biocatalysis witnessed turbulent growth and a sudden increase in the diversity of the underlying knowledge base.

According to this notion, search regimes characterised by large diversity can be found in all fields, but are more easily found in information, life and materials sciences, with nanoscience as the most recent and impressive case. Fields that undergo a proliferation dynamics are faced with a challenge: How is it possible to explore in parallel many regions of the unknown, while keeping under control the probability of failure and the costs? When the scientific dynamics is convergent, scientists are able to anticipate (of course, with large approximation) the time needed to reach the expected results. But when the dynamics is one of proliferation, there is no way to do so.

This characterisation has several implications. As above, let us examine first the impact on doctoral education. Under a proliferation dynamics, there is the need for massive exploration of many competing research directions at low cost. We suggest that the doctoral and post-doc systems are exactly this kind of machinery, if they are designed in a competitive way. In fact, under the Continental model of PhD education and the Mandarin model of recruitment of researchers, the directions of research are dictated, more or less, by incumbent scientists. It is with the Competitive models that junior researchers, moving from a competitive doctoral education, are able to explore largely unexplored regions. This is even more so if post-doc researchers are allowed to compete for independent research grants, in order to validate the hypotheses laid down in the doctoral dissertation.

Another implication comes from the peculiar type of uncertainty generated by proliferation. Under convergent regimes (say, in particle physics) there would be large agreement among scientists on the types of experiments and the kind of infrastructure needed. Governments must decide on large investments, but they can benefit from the unanimous consensus of the scientific community. Priorities are clearly spelled out.

What happens under proliferation? The recent experience of failures in the early development of AIDS vaccines is extremely informative (Fauci 2008a, b). Governments and the public opinion were persuaded that a large increase in funding, the use of compassionate use in registration, and the acceleration of clinical trials would have obtained rapid results in vaccines (Merito and Bonaccorsi 2007). However, the underlying knowledge regime is one of proliferation of highly specific hypotheses on the working of a virus whose genome mutates extremely rapidly. Although the overall HIV paradigm is firmly established (Grmek 1990), within this paradigm there is an enormous variety of sub-theories on specific working details, each of which is compatible with the high-level theory, but not (always) with competing sub-theories. There is no possibility to agree on a common research strategy, even with a large amount of money. Under these conditions, we suggest that funding agencies and private sponsors approximate the probability of success with past success. In other words, reputational mechanisms are powerful because success breeds success.

8.4.3.3 Complementarity

There are three forms of complementarity that are examined in the notion of search regimes: cognitive, technical and institutional.

Cognitive complementarity refers to the need for interaction, combination, or even integration, between bodies of knowledge that are traditionally organised in separate disciplines. New search regimes in information, life and materials sciences originate a strong cognitive complementarity. One important reason for this is that, particularly in materials and life sciences, they are based on paradigms that postulate the need for explanations based on the most elementary levels of reality, or methodological reductionism. Thus, for example, materials science was born from the need "to relate the new fundamental knowledge of matter to the behaviour of highly complex materials", requiring the collaboration between "organic chemistry, physical chemistry, metallurgy, and solid-state physics" (Amato 1997: 91). Similar dynamics of complementarity between disciplines have been generated in many areas of life sciences by the so called Molecular Biological Revolution.

Technical complementarity refers to the nature of experimental infrastructure. Big sciences such as particle physics, oceanography and astrophysics require large technical facilities and are the subject of a dedicated literature. Somewhat less explored is the requirements that new search regimes place on facilities: They are usually smaller, geographically distributed, shared, have a general purpose, and are associated to peculiar types of informational infrastructures (such as bio-banks, databases, or test beds).

Finally, there are reasons to believe that the need for institutional complementarity already discussed varies across the fields of science. We have argued elsewhere that in fast moving fields there is an increased need for scientific organisations to interact systematically with non-scientific ones, not only due to external or societal pressures on science, but because of internal epistemic pressures (Bonaccorsi 2010). Two main reasons are discussed here. First, in order to apply methodological reductionism to complex multi-layered phenomena (e.g. a disease), there is a need for scientists to address layers of reality that go beyond the laboratory setting, such as bodies, persons, groups, communities, societies, often in a naturalistic setting. These layers are not accessible without entering a structured negotiation with non-scientific organisations, such as hospitals, patient associations, regulatory agencies, epidemiologic or public health organisations, and the like. Second, there is an epistemic need for scientists to interact with industry in all those new fields (the last in order of time being nano science) in which there is a crucial feedback from the industry back to scientific discoveries.

What kind of challenges do these new forms of complementarity create for institutions of science?

With respect to PhD education and the recruitment of researchers, cognitive complementarity emphasises the need for a recombination of established disciplines. The ability of postgraduate programmes to sustain junior researchers in building a scientific curriculum across disciplines would be a premium. Another clear requirement refers to the mobility of researchers.

As with technical complementarity, the requirements here are financially less severe than in big sciences, but organisationally more challenging. In fact, large centralised experimental facilities can be organised with a variety of hierarchical governance solutions, while decentralised facilities require hybrid organisational forms, such as networks, alliances, or multilateral relational contracts of various kinds. These organisational forms can be considered as producers of intermediate collective scientific goods (European Commission 2009). They require certain flexibility of the legal system and of administrative practices.

With respect to institutional complementarity, it is difficult to summarise all sub-dimensions into a single requirement. On one hand, the interaction with non-business organisations may be promoted or inhibited for a large variety of specific legal or administrative arrangements (e.g. the organisation of public health). On the other hand, academia-industry relations may take a different shape if the industrial partner is the large incumbent company or the entrant startup. It can be said that large Continental European countries such as France and Germany exhibit a strong institutional complementarity between academia and large established companies (via mechanisms such as the mobility of careers between public administration and industry, or public procurement, or large industrial funding of academic research), while they seem to be relatively weak in complementarity based on newly created firms.

8.4.4 Fast Moving Fields and the Institutions of Science: Why Europe Lags Behind

Summarising the above discussion, it can be said that in fast growing and high-diversity fields, such as information technology, the key institutional elements are mobility, fierce competition for students and academic staff and fast growth in funding and education curricula. National systems whose institutions of science provide better conditions for meeting these requirements will perform better. In fast growing and strong institutional complementarity fields, such as life science, the key elements are again mobility, competition and fast growth, but also institutional flexibility at the boundaries, or the ability to foster long-term relations between scientific and non-scientific organisations.

These arguments are summarised in Table 8.7. According to this analysis, the emergence of fast moving fields in science places a number of challenges that may or may not be met by institutional systems. In another paper, we have argued rather sharply that the main reason for the European science lagging behind the US one, at least in terms

Table 8.7 Institutional requirements of search regimes in fast moving scientific fields

Dimension of institutions of science	Dimension of search regimes				
	High rate of growth	*Large degree of diversity*	*Strong cognitive complementarity*	*Decentralised technical complementarity*	*Strong institutional complementarity*
Creation of skills for research (doctoral education, post-doc)	Increase in cognitive distance and high opportunity costs	Need for large scale low cost exploration	Recombination among disciplines in the PhD curricula	Need for postgraduate programmes for the training of new generations to new experimental techniques	Industrial PhD
	Failure of Continental PhD model	Need for PhD mobility and competition			
	Need for PhD mobility and competition	Autonomy of post-doc as principal investigator			
Recruitment and career of researchers	Failure of Mandarin model	–	Need for cross-disciplinary mobility	–	Need for industry-academia mutual recognition of careers
	Need for large scale open competition				Career mobility
Public funding of research	Failure of political allocation model	Failure of centralised funding models	–	–	Multi-layer funding system
	Need for mechanisms for fast growth	Need for a multi-layer funding structure			Public-private partnership
Academic governance	Need to open new laboratories	Premium on reputational mechanisms	–	Need to establish rapidly new technical facilities at university level	–
	Need to start new educational programmes presidential model more dynamic				
Institutional complementarity	Fast growth requires rapid creation of working relations with non-scientific organisations	–	–	–	Industry-academia career mobility
					Ability to support startups in new fields

of quality and impact, has to do with the weakness of scientific institutions (Bonaccorsi 2007). More precisely, we have shown that European science is excellent in fields that grow less than average, while it lags behind in almost all fast moving fields, with life science and information technology as the main examples. On the contrary, European science is very strong either in fields that do not require strong complementarity (e.g. mathematics, and to a certain extent, chemistry), or in fields where complementarity is mainly of a technical type and can be managed hierarchically.

In fact, European science has developed separate institutions at the national, intergovernmental and European level for dealing with search regimes with strong physical infrastructure complementarities (e.g. high-energy physics, astronomy, space research, oceanography, nuclear technology). It is much more difficult to provide the required complementarities in terms of human capital within the common institutional framework to rapidly emerging fields. For example, there are few rapid growth mechanisms in European science (with the European Research Council as a long-awaited counterexample). Talented junior researchers have fewer opportunities for rapid growth than elsewhere.

Is there a systematic relation between the characteristics of the search regime and the institutional features of scientific systems? In other words, is it possible to ask whether some countries, or some variety of capitalism, perform systematically better than others in a particular scientific field?

In the cited paper, we suggested that European countries, with a few exceptions, are better equipped with their scientific institutions to deal with relatively stable search regimes (low rate of growth/low divergence) and with regimes characterised by a weak complementarity. These search regimes are found in traditional chemistry, physics, and mathematics. The big problem, as argued in that paper, is that the sciences born in the twentieth century, such as life, information and materials sciences, are all characterised by turbulent growth, divergent or even proliferating dynamics, and by new forms of complementarity, particularly cognitive and institutional complementarity. This offers an explanation on why Europe lags behind the US in all these fields.

If complementarities were weak, then the traditional institutions of Humboldtian universities could have arranged even a rapid dynamics. To make an example, France is still among the world leaders in mathematics. But when a turbulent dynamics in many competing directions is coupled with cognitive and institutional complementarities, then the European university model is bound to failure. What is needed here is institutional flexibility to arrange differential funding mechanisms, the rapid creation of human and technical infrastructure, a large mobility of students, and a fierce competition to attract top scientists.

8.5 Conclusion

What does this analysis tell us about the case of Germany in software- and biotechnology? First, we suggest that in the long run industrial competitiveness of science-based industries cannot be created without a world-class scientific and academic base. The roots of weakness of European high-tech industry lie, although indirectly and over many decades, in the inability of its scientific system to address the challenges of new search regimes. In both information science and life science there are not many German (more generally, European) universities or research centres with worldwide attractiveness, as measured against the historical record of excellence in other fields.

Second, in terms of our model, the German institutional scientific system can be characterised as being closer to the models of Continental doctoral education, of Mandarin researcher recruitment, and of Collegiate academic governance. These features, according to the predictions of our model, would militate against the possibility of strong performance in these fields, whose scientific dynamics (in information and life science, respectively) is subject to turbulent and proliferating search regimes. What about the other two dimensions of institutions of science?

The public funding system is very complex, with features of both Merit-based and Political allocation models. As Casper et al. (1999) have shown, the German government has invested large sums of money in research in these two fields, usually with large strategic plans.

Finally, institutional complementarities are strong, at least with respect to industry-academia relations. According to the *Main Science and Technology Indicators* of the OECD, Germany is the country in which the funding of Higher Education R&D (HERD) by industry is the largest, at 14.2 % in 2006, against an average of 6.3 % for the OECD. This structural characteristic is not new: In 1985 the German share was 5.4 %, against an average of 4.2 % for the OECD.

Why has not this feature of the German system supported vibrant software- and biotechnology industries? The reason lies in the distinction between complementarities with existing industry, or ability to create complementarities for new industries. The former performs extremely well in Germany, the latter does not. As the panel on technology transfer in the United States and Germany noted succinctly: "The German innovation system is organized to excel in the application of new technologies that increase the performance of existing industries. (…) The U.S. innovation system is structured to excel in opening up new technological frontiers and launching new industries" (Abramson et al. 1997).

Historically, the large incumbents in the German innovation system have played not only to attract resources for the system's own needs, but also to deter actively the growth of new industries. Germany had the opportunity to develop an independent computer industry after Second World War after the inventions of Konrad Zuse, but when his company was acquired by Siemens the technology came to a halt. Large German chemical and pharmaceutical companies actively tried to delay federal investment in research in biotechnology, fearing that their dominance of chemistry-based drug development could be harmed. Thus, the strong complementarity between industry and academia played against the emergence of new fields.

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Part III
Europeanising Research and Research Funding

Chapter 9
The European Research Council: A Legal Evaluation of Research Funding Structures

Thomas Groß and Remzi N. Karaalp

9.1 The Creation of the European Research Council

The European Research Council (ERC) was founded in 2007 on the Basis of the 'Ideas Programme' of the European Community's Seventh Research Framework Programme.[1] It is the first independent EU research funding agency for pioneer research, aiming at the strengthening of fundamental research in Europe by financing excellent projects of European researchers. The ERC is a core element of the European Research Area, a project initiated in the year 2000 by the Commission in order to increase the impact of European research efforts by strengthening the coherence of research activities and policies conducted in Europe (Commission of the European Communities 2000).

The roots of European research policy are mainly in the field of nuclear energy research (Pfeiffer 2003); but as early as 1971 the Joint Research Centre began to broaden its scope of research, branching out from the nuclear field into other areas. The Council adopted the First Research Framework Programme in 1983 without an explicit basis in the treaties. The basis was added only in 1987 by the Single European Act, creating the new chapter on research and technological development. The Amsterdam Treaty has broadened the scope of European research policy by inserting in Art. 163 para. 1 ECT the phrase saying that the "Community shall

[1] Decision No 1982/2006/EC of the European Parliament and of the Council of 18 December 2006 concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007–2013), OJ L 412, 30.12.2006, p. 1–43.

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have the objective of promoting all the research activities deemed necessary by virtue of other chapters of this Treaty". This new formula has ended the focus on technological development and opened the path for the EU to engage in fundamental research (von Bogdandy and Westphal 2004).

A second element of the discussion preceding the creation of the ERC was the critique on the political influence on European research funding procedures mainly by German scientific organisations pleading for the creation of an autonomous European funding agency (Max-Planck-Gesellschaft 1994; German Research Foundation 1997). This was supported by the legal argument, that there is a general principle of autonomy for research funding agencies that is binding also for the European level (Trute and Groß 1994). The European Academy and the European Science Foundation also pleaded in favour of the creation of a European Research Council (Academia Europaea 2003; ESF 2003). An expert group created by the Council of Ministers, which was chaired by Federico Mayor, delivered a report in 2003 recommending strongly the creation of a European Research Council to support investigator-driven research of the highest quality selected through European competition (Ministry of Science, Technology and Innovation 2003). The new body should operate autonomously because this was seen as necessary to obtain trust and credibility within the research community.

The formal foundation of the European Research Council was done with the special programme Ideas.[2] The field of the ERC is defined in the programme as "pioneer research", whereas the ERC prefers the term "frontier research". The aim is, according to the ERC, to stimulate scientific excellence by supporting and encouraging the very best, truly creative scientists, scholars and engineers to be adventurous and take risks in their research. Therefore two types of grants have been designed. The "Starting Grants" are for the best researchers with 2–10 years of experience after their doctoral degree. Each project can receive up to €2 million for a maximum of 5 years. The "Advanced Grants" are for top research leaders, with at least 10 years of experience and significant research achievements; the budget is up to €3.5 million for 5 years. Applications can be made in any field of research – including the social sciences and humanities – with particular emphasis on the frontiers of science, scholarship and engineering. Scientific excellence is the sole criterion for the selection of projects. Neither the nationality of the applicant nor political considerations are relevant. However, the ERC-funded research should be carried out in one of the 27 EU Member States or in one of the Associated Countries. The projects can be hosted both in public and private institutions.

The evaluation of the excellence of an application is done – as in all national research funding agencies – on the basis of peer review. As there is no "one size fits all" structure of peer review, the governance patterns of the ERC are important for

[2] Council Decision 2006/972/EC of 19 December 2006 concerning the specific programme: Ideas implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007–2013), OJ L 400, 30.12.2006, p. 243–271.

the evaluation of its work. This is especially true for the ERC as the calls in the first 3 years had an overwhelming resonance in the scientific community. The competition was so strong that the success rate for the Starting Grants was below 10 %, for the Advanced Grant below 15 %. Therefore the question is whether the ERC's organisational structure and its rules of procedure are able to create trust in the evaluation of applications necessary for the long term credibility of the new funding agency.

9.2 The Organisational Structure

The ERC is characterised by a dual structure, unique in the context of the European Union. It is the result of a compromise between the models of autonomous national funding institutions and the traditions of European administration. The idea is a strict separation between scientific tasks assigned to the Scientific Council and administrative tasks assigned to the ERC Executive Agency.

The Scientific Council sets the scientific policy of the European Research Council. It acts on behalf of the scientific community in Europe to promote creativity and innovative research. It defines and decides on the overall scientific funding and management strategy of the ERC, including an annual Work Programme where the calls for proposals and the corresponding funding rules and selection criteria are defined. The Scientific Council oversees the ERC's operational management and the implementation of the Work Programme, including the outcome of calls for proposals, the execution of peer review evaluation processes and the selection of peer reviewers, and the grant management. It establishes the methods and procedures for the peer-review-based evaluation, thus determining the basis for the funding of proposals. The Scientific Council will also assess the quality and the achievements of operations, and makes recommendations for improvements and future actions. In addition, it ensures the transparency of ERC operations by establishing an open information strategy. This strategy is reflected in the communication on the activities and achievements of the ERC with the scientific community and with stakeholders. The Work Programmes and the rules of procedure have to be approved by the Commission.

The Scientific Council is composed of 22 scientists, engineers and scholars of the highest repute and appropriate expertise, ensuring a diversity of research areas. The founding members have been nominated by the Commission on proposal of an independent expert committee, the first ERC Identification Committee headed by Lord Patten of Barnes, Vice Chancellor of Oxford and Newcastle Universities.[3] The term of office is limited to 4 years, renewable once on the basis of a rotating system ensuring the continuity of the Scientific Council's work. New members are appointed by the Commission following an independent and transparent procedure carried out

[3] The report is available under http://erc.europa.eu/pdf/final_report_erc_20062005_en.pdf. Accessed 12 April 2010.

by the new ERC Identification Committee since the first Committee has finished its work with the proposal of the founding members of the Scientific Council. The Identification Committee currently consists of four members appointed by the Commission. The identification procedure includes a consultation of the scientific community and a report to the European Parliament and the Council. The members of the Identification Committee and the Scientific Council act in their personal capacity, independent of extraneous interests, in particular of interests of their host institutions. The President of the Scientific Council is the formal representative of the ERC. A Secretary General is appointed by the Scientific Council and acts as its permanent representative in Brussels.

The evaluation of ERC grant applications lies in the hands of peer review panels. For the two funding schemes 25 Panels covering all fields of science, scholarship and engineering have been created. The panel chairs and the 10–15 members are selected by the Scientific Council. They may not only come from the EU Member States or the associated countries but also from third countries. In practice, the panel chairs play an important role in the evaluation process as they are responsible for the proper and fair peer review and take care of the rotation of the panel members envisaged by the Scientific Council. The panels are assisted by external scientific experts working as remote referees. The experts are selected by the Scientific Council, de facto the panels play an important role by making proposals. The formal appointment is done by the Executive Agency. The names of all panel members and external experts are published on the ERC website.

The legal qualification of the Scientific Council is problematic as it does not fit into the established categories of European organisation law. It might be qualified as a special auxiliary organ of the Commission. Under this heading, any institution deemed to support one of the main organs is classified (Streinz 2003). One might argue that the purpose of the Scientific Council is to support the Commission in the funding of pioneer research. The Commission appoints the members and it has to approve all important decisions like the Work Programme. On the other side, the independence of the Scientific Council is guaranteed by the programme Ideas. Therefore “support” for the Commission is not a precise definition.

All administrative tasks, e.g. the management of the evaluation procedure and the conclusion of the grant agreements, are assigned to the ERC Executive Agency. Although it was founded already in 2007, it became fully operational not until July 2009. It was created in order to manage exclusively the Ideas Programme, but on the basis of the general statute of executive agencies. It is managed by a Director and a Steering Committee, both appointed by the Commission. The majority of the members of the Steering Committee are representatives of the Commission, but one of them is also a member of the Scientific Council, and the Secretary General is admitted as an observer. The Director is appointed by the Commission for a 4 years term. The Executive Agency works under the supervision of the Commission which is considered necessary because of the responsibility of the Commission for the EU budget.

To ensure an effective link between the two constituents of the ERC, namely the Scientific Council and the ERC Executive Agency, the ERC Board has been created.

It is composed of five members, the ERC President and two Vice-Presidents, the ERC Secretary General and the Director of the ERC Executive Agency. The board prepares the plenary meetings of the Scientific Council and serves as platform for the exchange of information and ideas.

9.3 The Rules of Procedure

Once a year, the ERC publishes a call for the two grant schemes. The selection of the applications received starts with an eligibility check concerning the formal requirements. The check is carried out by the Executive Agency. In cases of doubt an eligibility review committee decides, while the peer review evaluation may proceed. All eligible applications are assigned to one panel, but in the case of interdisciplinary projects the applicant may mention a second panel in the application form.

All applications are evaluated on the basis of three criteria: the principal investigator, the research project, and the research environment. Additionally, fundamental ethical criteria are taken into consideration, e.g. the funding of human cloning is excluded, but this is relevant only in very few cases. In a first step all applications assigned to a panel are reviewed independently by three panel members. Then about twice the number of applications to be funded is admitted to the second stage.

In the second phase of evaluation the applications are assessed by three external experts. The experts give an individual judgement with marks for the quality of the principal investigator and the quality of the project, accompanied by a substantial explanatory comment. The rules of procedure deal with the detection of conflicts of interests, such as applicants', referees' or evaluators' significant collaborative, conflictual or ongoing mentor/mentee relationships, close family ties or close cooperation as colleagues in the same institution. In those cases the expert is disqualified and bound by contract to absent himself from further evaluation of the proposal concerned. For the Starting Grants all applicants admitted to the second stage are invited to an oral hearing of 30 min for a scientific discussion on the proposal. This is seen as a useful element of the procedure as the CV of young researchers does not always give sufficient information. On the basis of the review reports and the results of the oral hearings (for the Starting Grant), the panel sets up a ranking list with three parts. Category A is reserved for projects with the highest quality, category B is a reserve list falling below the budgetary threshold for the panel, and category C contains all applications to be rejected because their final scores fall below the success threshold.

All ranked lists from the panels are discussed in a panel chair meeting. The distribution of funds is guided by an overall assignment to the three main domains, 39 % physical sciences and engineering, 34 % life sciences, 14 % social sciences and humanities. 13 % are reserved to the interdisciplinary domain given special attention in the panel chair assessment. The final ranking list adopted by the meeting is approved by the Scientific Council. The grant agreements with the institutions of the successful applicants are concluded by the Executive Agency, which in some cases modifies the financial conditions. A transfer of the grant to another host institution is possible if good reasons are given. During the funding period, two scientific reports (mid-term and at the end of the project) and financial management reports at regular intervals are required.

All applicants are provided with feedback in the form of an evaluation report. It indicates whether the proposal has met the quality threshold and provides the scores and corresponding comments given by the panel and the individual reviewers. Nevertheless, the names of the panel members responsible for the proposal or the external referees involved are not disclosed. If an applicant feels that there has been a shortcoming in the evaluation procedure, he or she has the right to introduce a request for redress. The request will be considered by a special committee set up by the Executive Agency. There will be no re-evaluation by this committee, but if there is evidence of a shortcoming, the proposal will be given back to the regular evaluation procedure. All requests for redress are treated in confidence. In the first year the redress committee considered 245 redress requests relating to the 9,167 proposals submitted following the peer review evaluation at stage 1 (3 % of the total number of applications). The redress committee concluded that 15 of these cases (6 % of complaints) required a re-evaluation, resulting in one proposal being passed to stage 2. Following the evaluation procedures at stage 2, 27 cases were received and have been processed, but none were retained (Commission of the European Communities 2008: 6).

9.4 Evaluation of the Governance Structure

The organisation of the ERC is unique, because it is characterised by a non-hierarchical structure with strong links to the scientific community. For this kind of institutions the governance theory provides useful analysis tools (Mayntz 2009). Peer review is a fragile process which needs a combination of organisational and procedural safeguards in order to convince the scientific community and the general public of the statement that decisions are taken appropriately. The European legislator is responsible to adopt rules on a structure of peer review adequate for science (Lindner 2009). For this purpose a combination of several elements is necessary.

For the evaluation of the ERC, the Mid Term Review Report by an independent commission headed by the former Latvian president Vike Freiberga gives useful insights.[4] This review is required by the programme Ideas and aims in helping to develop the ERC as a learning organisation. During the preparation of this report, a questionnaire had been sent to applicants, panellists and remote referees. A large majority from all groups has confirmed that the selection process was in line with best international practices.

From a legal point of view, three elements of the procedure are of particular importance for the creation of trust in the fairness of the evaluation procedure. The

[4] http://erc.europa.eu/pdf/final_report_230709.pdf. Accessed 12 April 2010.

detailed rules on conflict of interest guarantee the impartiality of the reviewers. Obviously the anonymity of the evaluation reports prevents the applicants from checking whether a conflict of interest has arisen. But this is seen as necessary to encourage scientists to participate in the evaluation, as also most of the national research funding agencies guarantee the anonymity of evaluators. In addition, the publication of the expert names on the ERC website smoothes the negative effects which may arise from a complete anonymous evaluation. The second positive element of the selection procedure is the transparency of the evaluation because detailed reports are transmitted to all applicants.

A third factor is the existence of the redress procedure. Although it is used in rather rare cases and the success rate in the first years has been very low, the fact that applicants know that errors or flaws in the procedure can be corrected if necessary, is important. The right to complain is guaranteed also by most national funding agencies but not by the German Research Foundation (Groß et al. 2010: 177–178).

However, the organisational elements of the governance structures are seen with much more criticism than the procedures. On the one side the selection process of the scientists involved is problematic. On the other side the fundamental organisational structure of the ERC with the separation of scientific and administrative tasks is subject to critique.

The appointment of the scientists involved in the evaluation procedure of the ERC follows a cascade model. At the very top the high-ranking Scientific Council Identification Committee made the proposal for the selection of the 22 founding members of the Scientific Council. They were responsible for the selection of the panel chairs and – based on proposals by the chairs – the other regularly rotating panel members. The selection of the remote referees as the last step is done by the panel members. The rules provide for a consultation of the European scientific community, but in practice obviously personal relations were very important. In the Mid Term Review Report this has been classified as "somewhat amateurish practices". Obviously an election of the panels by all members of the scientific community as in the German Research Foundation (Groß et al. 2010: 59–60) is not a workable way for the European level, as there is much less integration and mutual knowledge, at least in most disciplines. Nevertheless transparent criteria for the selection of experts and a certain degree of diversity should be guaranteed. The Scientific Council has now created a permanent subcommittee to build a database of experts in addition to the list of experts resulting from calls for applications published in the Official Journal of the European Union.

According to the Mid Term Review Report, the separation between scientific choices and management is artificial and suboptimal and the filling of administrative positions in the Executive Agency, e.g. the filling of the positions of the steering committee or of the Director of the Executive Agency by renowned scientists, would be helpful. Certainly the independence of the Scientific Council has been respected by the Commission from all we know. Also the evaluation process by the panels is autonomous from external influence. The problem is that the statute of the Executive Agency and the rules on financial and personnel questions applicable to the Agency do not respect the peculiar requisites of basic research funding.

Therefore working in the Agency is not attractive for renowned scientists. The strict budgetary rules are not flexible enough for research purposes. Therefore the bureaucratic elements of this structure are not adequate to its tasks and cause high transaction costs. As the staffs of the Executive Agency are involved in all steps of the evaluation procedure and in the grant management, the supervision by the Commission might put the autonomy of the ERC at risk.

This dual structure is not compatible with national models of research funding agencies. The German Research Foundation has been founded as an association under German civil law by all German universities and research institutions (Groß et al. 2010: 56–59). The Board is elected by the General Assembly of Members. The Board proposes the Secretary General, who is the Director of the Administration, to the Joint Committee. Representatives of the research ministries of the Federal and Länder Governments are members of this Committee, but the majority of the members are scientists. The election of the panel members by the peers is part of the German self-government model with a long tradition. These features of the DFG organisation guarantee the autonomy of the institution. The French National Research Agency (Agence Nationale de la Recherche) was founded in 2007 on the basis of a statute and works as an autonomous public research institution (Wilden 2008). In the Board of Administration the members from scientific organisations are a small majority in relation to the representatives of government ministries. The Director-General, who is responsible for the selection of the panel members, is appointed by the Ministry of National Education, Advanced Instruction, and Research. But as a high scientific reputation is required, this seems not to undermine the autonomy of the agency, although the political influence is certainly stronger than in the case of the DFG.

Meanwhile the procedural safeguards for the evaluation process are best practice; however, the organisational structure should be modified. Art. 187 TFEU provides the legal basis for the Union to set up joint undertakings or any other structures necessary for the efficient execution of Union research, technological development and demonstration programmes. This flexible clause should be used to guarantee a complete autonomy of the ERC outside the statute of Executive Agencies. The debate started with the mid term review unfortunately did not lead to a modification of the ERC in the Eighth Research Framework Programme “Horizon 2020”. The dualist organisation with an independent Scientific Council and a dedicated implementation structure will also work in the years 2014–2020.

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Chapter 10
Supporting Frontier Research, Which Institutions and Which Processes

Some Initial Considerations

Philippe Larédo

10.1 Introduction

The purpose of this chapter is to discuss the relevance of the European Research Council as an engine for promoting 'frontier research' in Europe and for bridging the perceived gap highlighted by most policy documents of the early 2000s.

There have been many analyses of the rationales and processes that explain the creation of the ERC. Many analysts see its roots deep in the construction of the European Community, and more specifically at the creation of the European Commission and its perspective about European research with its four dimensions (Guzzeti 1995; André 2006; Larédo 2009). Nedeva (2010) proposes an elegant answer to the unfolding of the ERC with her notion of science built as a relationship between "research fields" and "research spaces".[1] She sees the ERC as an answer to the tension "between the inherently global nature of the research fields and the localised, mostly national, research spaces". Nedeva suggests that such a social process can only materialise if three conditions are fulfilled. First, a change champion is important (here the elite of life sciences, see the 2003 Paris meeting organised by ELSF and EMBO). Second, some level of institutionalisation and organisation

[1] "Research fields" are empirically outlined by three inter-connected elements, namely converging knowledge communities, consistent bodies of knowledge and research organisations. "Research spaces", on the other hand, are defined by the 'essential' relationships of the research organisations and by notions of the utility of knowledge. The emphasis is on the relationships and on the exchange(s) in which the organisational actors are involved rather than on the attributes of the organisations.

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building (here the Commission which strikingly changed its views on the issues within 1 year, see Dublin Conference 2004) is necessary. Third, the progressive emergence of conditions (commensurability of funding rules, organisational set-up for research) that render the enlargement audible by national spaces needs to be realised. Here it is the dominance of the agency model of funding with in particular the creation of the French ANR, and the central role given to universities as research performers in most countries at the turn of the twenty-first century.

I fully share this approach. There is, however, one aspect that is not explained with this analysis that is the institutional focus given to the ERC: The ERC is not only dedicated to funding academic or fundamental or basic research, the classical OECD categories, but it is also focused on 'frontier research' as is well outlined by the few extracts taken from the 2008 Work Programme (Box 10.1; ERC 2007). At the same time these extracts show that the concept is not that clearly established: Is the research 'frontier', or is it 'frontier' because it is located at the 'frontiers of knowledge' (which could correspond to the fields that the ISI Web of Knowledge qualifies as 'research fronts'), or is it qualified as such because it is 'unconventional' (others say heterodox) and/or of a 'ground-breaking nature'?

The focus of this chapter is not to inquire how such a focus was arrived at. It is to take it for granted and discuss the coherence of this objective with the organisational arrangements arrived at.

Section 10.2 will focus on frontier research as a politically driven concept looking on both sides of the Atlantic. Section 10.3 will link these politically driven developments to existing literature not in a view to delineate this concept further but with the objective to grasp its institutional and organisational contents. This will help to identify key organisational conditions for the implementation of a policy objective that would be to increase the amount of frontier research undertaken in Europe. Finally, personal views will be elaborated about the future of the ERC.

Box 10.1. Extracts of the 2008 Work Programme of the ERC

- The fundamental principle for all ERC activities is that of stimulating investigator-initiated frontier research across all fields of research on the basis of excellence.
- Support of excellent, innovative investigator-initiated research projects
- ERC Advanced Grants provide an opportunity to established scientists and scholars to pursue frontier research of their choice.
- Advanced Grants are intended to promote substantial advances in the frontiers of knowledge, and to encourage new productive lines of enquiry and new methods and techniques, including unconventional approaches and investigations at the interface between established disciplines.
- (Projects should) demonstrate the ground-breaking nature of the research.

10.2 Frontier Research as a Politically Driven Concept

In the recent work done on rationales for research and innovation-policy making, Bach (2007) highlighted the existence and interplay of two sources: production policy rationales and governance policy rationales, the former being associated to scholarly conceptual developments and the latter deriving from practice and causal beliefs built within the course of political action. This symmetrical approach to constructs that are mobilised by policymakers is specifically useful here to address the notion of 'frontier research'.

We all know the 1945 report by V. Bush, "Science The Endless Frontier" (Bush 1945). However, the term 'frontier research' does not resonate much in academic work. A quick overview shows that its main use is linked to agenda setting for discussing the challenges faced by disciplines or derived from new issues (cf. e.g. Baltes and Smith (2003) on the future of ageing or Berkowitz et al. (2003) on urban ecosystems). The other central use has also been operational, with Scientometrics and ISI identification of 'research fronts'. This explains why I focus first on 'governance policy rationales'. A number of initiatives have been recently developed under this conceptual umbrella: the European Union ERC and the US Department of Energy initiative on "Energy Frontier Research Centers". Other agencies in the US, following the National Science Board (2007), have devised a related concept of 'transformative research' and have embedded it in their activities.

There has been quite a number of official texts about the ERC (for a review, see Nedeva 2010); however, the only one to attempt a detailed definition of 'frontier research' is the report of a high level group set up by the European Commission (2005). Some members of this group are central figures in the field of science policy studies, e.g. Ben Martin, Stefan Kuhlmann, Andrea Bonaccorsi or Paula Stephan. The report highlighted four central characteristics for this new terminology: Being at the forefront of new knowledge, being risky and uncertain, potentially merging the classical dimensions of applied and basic research, and pursuing questions irrespective of established disciplinary borders (see Box 10.2 for an enlightening paragraph).

Box 10.2. Defining Frontier Research: The HLEG 2005 Report (p. 18)
"Classical distinctions between basic and applied research have lost much of their relevance at a time when many emerging areas of science and technology (e.g. biotechnology, ICT, materials and nanotechnology, and cognitive sciences) often embrace substantial elements of both. We therefore prefer to use the term frontier research to basic research to reflect the following characteristics:

1. Frontier research stands at the forefront of creating new knowledge and developing new understanding. Those involved are responsible for fundamental discoveries and advances in theoretical and empirical understanding, and even achieving the occasional revolutionary breakthrough that completely changes our knowledge of the world.

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2. Frontier research is an intrinsically risky endeavour. In the new and most exciting research areas, the approach or trajectory that may prove most fruitful for developing the field is often not clear. Researchers must be bold and take risks…
3. The traditional distinction between 'basic' and 'applied' research implies that research can be either one or the other but not both. With frontier research, researchers may well be concerned with both new knowledge about the world and with generating potentially useful knowledge at the same time (as with the concept of Pasteur's Quadrant developed by D. Stokes)…
4. Frontier research pursues questions irrespective of established disciplinary boundaries. It may well involve multi-, inter- or trans-disciplinary research that brings together researchers from different disciplinary backgrounds, with different theoretical and conceptual approaches, techniques, methodologies and instrumentation…"

Box 10.3. Locating and Defining 'Transformative Science' in Science Dynamics

Source: National Science Board (NSB 2007)

> Science progresses in two fundamental and equally valuable ways. The vast majority of scientific understanding advances incrementally, with new projects building upon the results of previous studies or testing long-standing hypotheses and theories. This progress is evolutionary—it extends or shifts prevailing paradigms over time. The vast majority of research conducted in scientific laboratories around the world fuels this form of innovative scientific progress. Less frequently, scientific understanding advances dramatically, through the application of radically different approaches or interpretations that result in the creation of new paradigms or new scientific fields. This progress is revolutionary, for it transforms science by overthrowing entrenched paradigms and generating new ones. The research that comprises this latter form of scientific progress (is) termed transformative research…This pathway is marked by its challenges to prevailing scientific orthodoxies.

The US National Science Board in its report on transformative science (2007) proposes a quite similar definition but locates it within an overall view of the dynamics of science. It suggests a differentiation between evolutionary and transformative science (see Box 10.3). The report explained why NSF is poor at doing it (see later) and proposed the development of a new initiative. The NIH Common Fund (2004) made the same analysis. But both agencies have selected different approaches to address it: The NIH has developed a specific programme with its pioneer awards 'to support individual scientists of exceptional creativity' while the NSF has chosen to add one selection criterion in all of its panels ("To what extent does the proposed activity suggest and explore creative, original, or potentially transformative concepts?").

The DOE offers a very different answer, which is simultaneously procedural, cognitive and organisational. It is based on an initial strong assumption: 'Incremental advances in current energy technologies will not address the energy challenges of the twenty-first century. History has demonstrated that radically new technologies arise from disruptive advances at the science frontiers' (DOE 2008: 2).

The de facto definition proposed first accounts for a process that started in 2001 with the work of an advisory committee (Basic Energy Sciences Advisory Committee, report in 2003 cf. US Department of Energy 2003) followed by 'basic research needs workshops' gathering 1,500 participants over the next 3 years and producing each a specific report (12 in total). These in turn enabled to identify 'scientific challenges which no longer were discussed in terms of traditional scientific disciplines' and which 'described a new era of science—an era in which materials functionalities would be designed to specifications and chemical transformations would be manipulated at will' (US Department of Energy 2003: 3). This de facto definition thus entails a second dimension: It is not only procedural, but it is also cognitive: Frontier research relates to given challenges or problems, and it is associated to potentialities offered by sciences to address them. To discuss frontier research, one needs to enter into contents. The core of the DOE (2008) text is about describing the five 'science grand challenges' identified.

The third component of 'frontier research' builds an organisational answer: 'Energy Frontier Research Centers' will bring together the skills and talents of multiple investigators to enable research of a scope and complexity that would not be possible with the standard individual investigator or small group award' (US Department of Energy 2003: 4).

These politically driven rationales propose a similar vision of the dynamics of science. Mostly they share definitions of what is looked for; however, they widely differ in the ways of implementing it. While the DOE initiative focuses on centres, Europe has created a new funding agency, the NSF proposes to include a new criterion in its panels and the NIH has established a new initiative based upon individual scientists. These different organisational answers raise questions about the reasons that underpin them. They also drive us to consider the theories and concepts that underlie them.

10.3 Conceptual Background to 'Frontier Research'

How does this politically driven construction relate to established theories? Should it drive us to develop new conceptual frames, as was the case at the beginning of the 1980s to face the construction by policymakers of a new type of policy instrument, collaborative or technological programmes (Callon et al. 1997; Larédo et al. 2010)? My tentative answer is no, considering that two established streams help us address the organisational issues raised.

One stream derives directly from the science dynamics proposed (especially by the NSB) which has strong connections with work done in innovations studies on breakthrough innovations or disruptive technologies, at the encounter of economics, management and sociology. It further resonates much with the very classical work about Kuhnian science dynamics. This stream focuses on processes through which transformation occurs, and one important dimension is about how new scientific or technological paradigms, new breakthrough products and services are institutionalised and how adoption and generalisation take place.

Following Nedeva's approach, such transformations deal with the reshaping of research fields, their boundaries and the communities that they entail. We are there associated to a long tradition of sociological studies dealing with the structuration of fields and the elegant theorisation by Diana Crane of invisible colleges (Crane 1969) and subsequent work on transepistemic communities and changing modes of production (with the famous 'Mode 2' of Gibbons and et al. 1994). This offers one way of taking account of diversity by establishing peer-based selection processes within all-embracing institutional settings. New approaches to knowledge dynamics, and in particular the works of Bonaccorsi (2005, 2008), question whether this is enough to take into account the diversity of 'search regimes' and the institutional conditions that favour or constrain their growth. Said otherwise, can there be 'one size fits all' institutional answers to different knowledge dynamics?

10.3.1 Frontier Research as a Process: Organisational Implications

The classical reference is clearly linked with Kuhn's approach of science dynamics (Kuhn 1962). One can see the use of 'frontier research' as a call for more support to those research activities that question established paradigms, which organise normal science. In technology, evolutionary economists have also highlighted the role of technological paradigms (Dosi 1982) and have associated the long-term dynamics of economies to shifting paradigms. Whether qualified as radical or breakthrough innovations, or disruptive technologies, there is an important body of work to analyse the journeys through which such transformations take place (Cheng and Van de Ven 1996). Studies have focused on the emergence of new designs or paradigms and on the ways in which those designs and paradigms become dominant. Abernathy and Clark (1985), Tushman and Anderson (1986) and others propose a convergent approach to these transformation dynamics.

The core of innovative activities undertaken are cumulative and come to deepen and reinforce the 'dominant design' (here the dominant paradigm). This is the normal state of affairs or normal science. There are different views to explain the progressive exhaustion of this dominant design. The two main explanations put forward for innovation deal with the trivialisation of the knowledge base and with the progressive exhaustion in the exploitation of market segmentation. The former drives to a competition via prices ('produce the same thing cheaper') and the second one focuses on deepening differentiation associated to stronger and stronger connections with different 'lead users'. Whatever the reasons, this provides incentives for inventors and innovators to try and pursue alternative alleys. Proponents of dominant designs speak of breakthrough innovations not as one off events (Collarelli O'Connor and Rice 2001), but as a progressive unfolding of new designs with often a long fluid phase whereby options to turn the new approach into innovations multiply and compete. This raises strong debates about the 'narrowing process' that will drive to the emergence of a dominant design and the conditions which those 'market shaping' activities have to address (Courtney et al. 1997).

Recent analyses highlight three complementary and intertwined dimensions: technological, utility (as perceived by users), and institutional, the latter dealing with rules (the North way), regulations and infrastructures that support them (such as patent offices for IP or drug authorisation agencies for the pharma industry). In turn, this has shed light on processes that enable such processes to take place: We for instance have developed instruments for managing the 'societal robustness of breakthrough innovations' (Larédo et al. 2002), which emphasise organisational issues, both in term of 'implementation structures' (Rip and Nederhof 1986) and of operational aspects (the portfolio of instruments mobilised). A later study on the emergence of a new approach to chip design, asynchronous logics, on the International Technology Roadmap for semiconductors (ITRS) showed that not only the portfolio of instruments was important, but also the sequence and conditions of their deployment (Delemarle and Larédo 2008).

From this parallel, I derive a first line of interrogation about developing frontier research in Europe: Organisational dimensions are critical to the materialisation of the objective followed. Furthermore, we should not only consider the overall 'implementation structures' established, but also the portfolio of instruments proposed and the conditions of their deployment.

10.3.2 Knowledge Dynamics, Search Regimes and the Need for Specificity

There is a lasting tension about work done on scientific production. On one side, there has been a constant search for a generic approach to structure government intervention. Merton's republic of science has witnessed two main institutional materialisations in the 1950s, the US vs. the Soviet or the British vs. the French models, putting universities and principal investigator-project based funding at the core on one side, or making of dedicated research organisations and research collectives the central mechanisms on the other. Germany was then a clear outlier having developed a balance between both. Of course, this was only the dominant feature and both co-existed in the different countries. Moreover, we all know about the strong blurring of these differences during the last 20 years, but the constant search for a generic approach to the research system remains.

On the other side, empirical work has emphasised the importance of differences between fields, between big and small science, between experimental and theoretical, between laboratory-based vs. observational, between curiosity vs. problem-solving driven among others. The most elegant theorisation of this variety for me still lies in the work by Diana Crane on invisible colleges (Crane 1969). Colleges, however, are not so invisible, they only exist through all the tangible and intangible infrastructures required to maintain them. Together they provide a powerful definition of what an established 'field' or 'discipline' is. Some play at the level of the discipline itself (in particular journals, conferences, prizes, professional associations), while others are embedded into national and local organisational settings (in particular teaching curricula, departments and/or research groups). At government level, this approach enabled to operationalise the Mertonian republic of science, embedding diversity by transforming invisible colleges into institutional constructs based on peer reviewing (in agencies or research organisations). In a way, research fields were collapsed into research spaces, a few nations being central in this process. In addition, we would now face the limitations associated to this assimilation, especially in smaller or mid-size states, as are European countries.

Three aspects of later developments are of importance for our discussion: the universe of actors that populate these colleges, the connections between 'disciplines' and the internal vs. external sources for agenda setting. Readers will recognise the work done by Knorr-Cetina (1982) on transepistemic arenas of research, all the issues associated with inter-, multi-, pluri- or trans-disciplinarity, and the ever-growing discussion on problem-solving research and the Third Mission of universities.

They join in building a new 'storyline' on the production of knowledge. The idea is that societal pressures (and in particular from firms faced with difficult problems, such as offshore exploitation 40 years ago) propose new challenges to science, lead to new interactions between discipline-based knowledge and, in a few cases, lead to paradigmatic shifts and the emergence of new communities. We face a beautiful example with homogeneous catalysis and the 2008 Nobel Prize given to one researcher employed by a mission-oriented institution (Chauvin from the IFP) that has been at the birth of a completely new speciality within chemistry.

From these developments, we can deduce that conditions under which new 'frontier' knowledge is developed differ widely between fields. A conceptualisation like this of Stokes (1997) that is often mobilised when discussing 'frontier research' (with his Bohr's and Pasteur's quadrants) is at best a categorisation of existing situations. Bonaccorsi (2005, 2008) has proposed a new approach to these differences with his three dimensions of 'search regimes': rate of growth, complementarities (cognitive, technical and institutional) and degree of diversity. Using this approach, I have shown (Larédo 2006, 2009) at the macro level how different production conditions have been for the successive leading sciences of the time, and how it interacted with institutional conditions (see also Bonaccorsi 2008). In a recent paper (Larédo et al. 2010), we underline that the trend to replicate policy mixes and instruments that worked well in preceding waves often prevailed before new mixes were developed, that better fit with the on-going dynamics (see the striking examples of the French Plan Calcul for information technology or Nixon's war against cancer).

To follow Nedeva's terminology, these elements tend to highlight the clear interaction between the dynamics of fields and this of research spaces. Institutional 'one size fits all' solutions might have very different effects depending upon the dynamics of different fields (see Chap. 7 of Jansen et al. in this volume). Thus, we should take into consideration the research fields – research spaces coupling not only in a spatial dimension (moving from the national to the European level) but also in its cognitive dimension: Which different mechanisms are needed within a research space to cater for the variety of research dynamics? This may well explain why in the US 'research space' answers proposed by the NIH widely differ from those developed by the DOE.

10.4 Reflecting upon Organisational Issues for European Developments

Focusing on the European situation I derive from the above developments that it is not enough to decide to create a global 'implementation structure' (the European Research Council). Operational aspects are critical and need to deal not only with the portfolio of instruments mobilised and their conditions of deployment, but also with their ability to cater for different dynamics: What might be relevant for some biotechnology developments may not be adapted for, say, nanotechnology-based new materials.

In order to discuss these points one has to unveil more details of the ERC's organisation. The central mode of the selected operation is peer reviewing. The ERC has created 25 panels to cover the whole range of science domains (more than 340 areas or specialities singled out). It only works out through calls and has devised two instruments addressing single principal investigators: the starting grant scheme and the advanced grant scheme.

This situation requires that we address two complementary issues:

1. Does such an organisational setting favour or hinder the selection of 'frontier science'?
2. Does it fit to take into account different knowledge dynamics?

10.4.1 Peer Reviewing and 'Frontier Research'

Even the 'greatest' supporters of peer review in their 'systematic review' (Wood and Wessely 2003) concluded that they "are unable to substantiate or refute the charge that peer review suppresses innovation in science" (p. 14). They account for the work of Horrobin (1990, 1996) and relay the strong interrogations by R. Kostoff, a well known specialist of evaluation procedures. Their citation of the 1977 Nobel Prize winner, Rosalyn Yalow, is typical of this: "the need to promote scientific revolutions and the outcome of peer review are in opposition" (Wood and Wessely 2003: 26). Should we then consider, with Horrobin and others, that peer review is malformed for

Box 10.4. NSB Analysis About Why the NSF Has Difficulties to Fund 'Transformative Research'
Source: NSB (2007)

- In practice, distinguishing between innovative and transformative research is difficult at best and, some would argue, only possible in hindsight. Indeed, the two forms of scientific progress do exist side-by-side and, often, proceed hand-in-hand and overlap each other.
- Transformative research frequently does not fit comfortably within the scope of project-focused, innovative, step-by-step research … nor does it tend to fare well wherever a review system is dominated by experts highly invested in current paradigms or during times of especially limited budgets that promote aversion to risk.
- The Board finds that investigators are reluctant to submit radical or paradigm-challenging research ideas to the NSF given the low conventional success rate. …
- Experts in the areas being challenged (many of whom may sit on review panels) may dismiss such ideas by pronouncing the research overreaching or without basis.

funding frontier research? The conclusions by NSB go in that direction (see Box 10.4). Still one has to recognise that even long ostracised Nobel prize winners such as Prusiner were funded by the US funding agencies.

Looking at interdisciplinary grant committees, Lamont et al. (2006) propose a more nuanced answer. Analysing how committees build their criteria and rules, they show that "procedural fairness" is warranted on "respecting disciplinary sovereignty", that this drives towards recognition and acceptance of "epistemological styles" but also allows reviewers to have "their tastes and idiosyncrasies …": As mentioned by one of their interviewees, "excellence is in some ways what looks most like you". From these results, I infer two central conclusions.

First I consider, following others (Knorr-Cetina or Schimank to mention a few), that epistemic communities largely frame the behaviour of reviewers, who will tend to respect and thus reinforce disciplinary standards. This applies not only for criteria of success "robustness" (what makes good proposals) but also for topics addressed. By this, I mean that most researchers share the research agenda of their discipline or speciality – what they recognise as the important questions to address. Committees are thus faced with two types of issues: one dealing with 'empirical rigor' (is there one or more epistemological styles considered?),[2] and one dealing with 'positioning' (is this part of the research agenda of the discipline/speciality?).

[2] Here I adopt the categorisation proposed by Mallard et al. (2009) with its four types: constructivist, comprehensive, positivist and utilitarian.

This enables to rephrase the issue of frontier research as those cases that do not follow dominant disciplinary styles and/or position themselves outside the 'mainstream' research agenda.

Second, I take it for granted that committees are quite good at curtailing the long tail of 'bad proposals' (van der Besselaar and Leydesdorff 2008). Thus, we should only consider the other cases. There I distinguish between normal science – or what the NSB calls evolutionary science (projects well located in the mainstream agenda with robust accepted methodologies) – and other projects. My second assumption (based on a long-standing practice and multiple anecdotal evidence, again a source for more systematic research), is that committees are quite good at identifying 'evolutionary' projects and at recommending them for funding. Committees only then appraise these other 'interesting' but 'unorthodox' projects, making of 'frontier research' a leftover after having addressed the pressure for satisfying the mainstream agenda.

Why should then the ERC, having a similar approach to selection processes, differ in its outcome? We can then anticipate, especially when taking into account the level of pressure observed (well under 20 %), that a large portion of the work supported will be 'evolutionary' rather than 'frontier'. Thus, we can assume that only one fraction of the 5 years anticipated €7 billion will nurture 'frontier research' – redefined as research that does not follow dominant disciplinary styles and/or is positioned outside the 'mainstream' research agenda.

10.4.2 Can the ERC Help Coping with the Perceived Difference Between Europe and the US?

It thus leads to a complementary issue: Can the ERC help coping with the perceived gap between the US and Europe in 'frontier research'? We shall see that discussing this issue drives to focus on our second question: Can it accommodate different knowledge dynamics?

At the end of the 1990s in Europe, we had a lively discussion on the European paradox (Caracostas and Muldur 1997): Europe is good in science and poor at transforming it into innovation. As soon as the paradox was issued, there were voices to demonstrate that this was untrue. Focused on science-based industries, and looking at science shaping new directions and new paradigms (manifested by highly cited researchers or Nobel prizes), Europe was no longer leading, it was mostly strong in cumulative areas and weak in new fast growing fields (Dosi et al. 2006; Bonaccorsi 2007 for the versions published). How then can we explain that spending an investment as great as in the US drove to such a 'poor' record? Was it because there was a constant brain drain? Working with the NSF (see Larédo 2004), a check was made on 30 years of US Nobel prizes to demonstrate that almost all of them had done their prize winning research in the US and that this could not explain a 1–2 ratio in Nobel prize winners. The EC translation was that research performers were too fragmented, thus that it was important to introduce a process of amalgamation. This provided a background rationale for the development of Networks of Excellence and of the European Institute of Technology. Again voices rose to challenge this opinion, showing that the problem did not lie in research groups being "sub-critical", but that it was associated with institutions themselves, and in particular with institutions in charge of the allocation of resources.[3]

Could then the European Research Council be THE solution? In order to address this issue, I developed a conjecture some time ago taking into account the different institutional settings between both spaces and estimating the respective levels of 'frontier research' faced with a similar level of overall investment. Box 10.5 presents the overall reasoning and the conclusions arrived at. This conjecture helps to highlight, why, with similar investments, there should be three to four times more frontier research – and Nobel prizes – in the US than in Europe. This is not an issue of intelligence or attractiveness, it is an organisational issue, which has been intuitively identified by European policymakers and coined under the term of 'fragmentation'. Here, fragmentation is not an issue of research performers, but an organisational problem in funding mechanisms to academic research overall, having strong consequences on the levels of funding dedicated to "frontier research".

Box 10.5. A Hypothesis on the Reasons of the EU-US Difference in 'Frontier Research

Source: Larédo (2004)

Let us consider a specific area, for instance catalysis in chemistry (see Kuhlmann and Laredo 2007). Let us make the following starting hypothesis: Overall efforts in this area are similar in Europe and the US.

In the US, the core of public funding is concentrated on a few Federal Agencies, here NSF, DOE (Department of Energy) and DOD (Department of Defence). In other fields, the NSF will be replaced by the NIH and the DOD may be replaced by the newly created Department of Homeland Security (DHS). These few agencies are used to coordinate and to share tasks (even if it is never easy), as is well illustrated by the "National Nanotechnology Initiative" (NNI). For the same field in Europe we shall have to account for at least ten agencies with meaningful activities complemented by at least four to five "National Programmes", as is well illustrated by the two ERA-NETs in Chemistry and in Catalysis. This case is further simplified since there is no FP-specific programme to add to the picture.

(continued)

[3] For a full demonstration, see the report "Challenging Europe's Research: rationales for the ERA" by the ERA Expert Group (2008).

(continued)

Analyses done have often shown that 'research agendas' clearly identify the research directions at short and medium term, and that long-term issues identified are in continuity with the prevailing 'dominant' paradigm. And the analyses have shown that, to anticipate on a new breakthrough direction, it is better to leave "a thousand flowers bloom", thus leaving room in the allocation of resources to unanticipated bottom-up initiatives.

Let us now suppose that for catalysis research, the three main US agencies spend 100, that 70 is focused on the "mainstream agenda" and that 30 support different options which we suppose to be "frontier research".

What will happen in Europe? There are large enough communities and strong exchanges, so that anticipations made are shared on both sides of the Atlantic. As each national agency has strengthened its management over time, they will ask for achieving critical mass, and even if the whole mainstream agenda is not covered, this will drive the agency to focus more means to this agenda. Globally, the agencies in Europe will probably devote 85 of the 100 they invest on the mainstream agenda in order to enable their national teams to remain globally competitive. In the end, Europe will over-invest on the mainstream agenda, which exploits present paradigms.

Furthermore, as there is no coordination between the ten main agencies or programmes, there will be significant redundancy in the 'frontier research' supported.

Twice less funds, associated to strong redundancy, produce, with equal investments and human capabilities, between three and four times less options being explored. Moreover, if we accept that there are similar success ratios between both sides of the Atlantic, they produce between three and four times less 'nobelisable' science… which is exactly the ratio observed in term of Nobel prize winners over the last 30 years.

10.4.3 Coping with Diversity in Knowledge Dynamics: The ERC as the 'Agency of Agencies'?

If we follow the reasoning pushed by such a conjecture, the central issue is not to add another independent agency in the already fragmented European landscape of funding, but rather to discuss how the existence of this new fund could lead to a greater amalgamation of funding bodies in Europe. My answer is that it could become the 'agency of agencies'. Let me explain this apparently exotic solution.

We do not start from an empty space. There is a long tradition of bilateral collaborations between funding agencies, even if funds mobilised are generally small. Of course, research organisations and funding agencies inherit the outstanding failure of the ESF in terms of amalgamating their means. Many observers were sceptical when the Commission proposed the ERA-NET instrument. Five years later, the surprise was the other way round. How could it be that it had been so attractive? And even if we will without doubt count many short-lived experiences, this has demonstrated that in many cases national agencies were interested in joining in specific areas and for specific issues. Even if it is anecdotal, not the European Commission but an ERA-Net has issued the largest European call in social sciences on a given topic, migrations. And this short-lived ERA-NET has given rise to a now joint DFG – ANR – ESRC – NWO Joint Call. This shows that times have changed and that the idea of the targeted pooling of resources is no longer just a 'dream' and could be seriously fostered by EC incentives, as seems the case in 2010 when dealing with toxicology issues of nanotechnology. This latter ERA-NET also highlights another dimension: Funding agencies have taken up the specific construction by actors of the need for a European-level action and discuss about original mechanisms to implement it. This ability to take into account the specific knowledge production requirements is reinforced by anecdotal evidence, comparing for instance the strong differences in the positioning and projected developments of the two ERA-NETs dealing with chemistry.[4]

This builds a learning path. The next step would be that the ERC does not use all its funds in its own 'all over the board' calls, but keeps a significant share to experiment, together with national agencies, new forms of 'joint programming'. ERA-NET-like structures with national agencies would be in a position to accommodate developments such as this made by the DOE with its procedural, cognitive and organisational dimensions. It would not break from the central requirement of competitive funding but would adapt it to the perceived needs of the area looked at, and to the anticipated 'basic research grand challenges' (to use the DOE terminology). One issue is about the identification of areas/issues that require such approaches: One option could be the development of a forum of funding agencies with multiple processes, including bottom-up calls for wanted 'basic research grand challenges'; lessons for this could be derived from the ESFRI forum for European-level research facilities that has demonstrated its ability to operate such processes. This is what I call turning progressively the ERC into the agency of agencies.

10.5 Conclusion

It is not because new concepts emerge from political dynamics that they should be considered as fashions, which will fade away. Collaborative research was born this way. This is why we should take seriously this political urge to consider 'frontier research'.

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[4] See PRIME (2007), Bonn Conference.

What I have tried to show is that we have both the conceptual apparatus and the organisational knowledge to address it. It leads to very different paths from the one presently being followed at EC level. And one could even say that there are intuitions of this within quite a number of governments that advocate for more 'joint programming' on grand societal challenges. Whether we need to wait for an anticipated failure to generate a substantial level of 'frontier research', or whether we can influence the trajectory followed remains to be seen!

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Chapter 11
Changing European Governance of Research: A Public Law Perspective

Arne Pilniok

11.1 Introduction

Traditionally, the Framework Programme has been a synonym for European research policy for decades. European governance of research was based on competition between researchers, research organisations and industry for research funding that was more or less exclusively organised by the Framework Programme. It thus was solely a distributive policy aligned to the direct implementation by the European Commission, which is seen as a central path dependency in European research policy (Banchoff 2002; Lavenex 2009). With the introduction of the political concept and – later – the normative goal of creating a European Research Area (ERA) in 2000 a second phase of research governance within the Union started. The key notions behind this concept were and are "fragmentation, isolation and compartmentalisation of national research efforts and systems and the disparity of regulatory and administrative systems" (European Commission 2000: 7). They are – in short – seen as causes for a number of problems diagnosed by the Commission. As a solution, the Commission proposed the creation of an 'internal market for research' that comprises, inter alia, an increased coordination and cooperation between Member States' policies and programmes.

When the European Union introduced the concept of the European Research Area, this also marked a shift in governance modes. This article focuses on the changing European governance of national research policies and research funding. It combines legal analysis with the theoretical insights of governance as an analytical perspective. The study can thus draw on the analytical framework for research governance (Pruisken and Jansen in this volume) as well as multi-level governance

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in general (Benz 2007a, 2009). Hierarchy, negotiations, networks and competition are the central modes of coordination, which can be found in different combinations and patterns (Benz et al. 2007). Each of these modes and their combination links legal and non-legal elements (Trute et al. 2008).

Central assumption of the chapter is the emergence of a ‘European research administrative space’ (Langfeldt et al. 2012: 90; Pilniok 2011: 4), drawing on observations made for the development of the public administration in the multi-level system of the European Union in general (Egeberg 2008). As institutions are essential for the establishment of an European dimension, creating an European Research Area therefore implies both institution-building and changing existing institutions. The shifting forms of “executive governance in EU research policy” (cf. Gornitzka 2012) oscillate between the persistence of the traditional modes of direct implementation and new forms of governance, which connect European and national actors in research policy and research funding and thereby create a ‘third layer’ between the European and the national level of governance.

Within this theoretical framework, the following questions are examined: Which governance structures are used and established in order to integrate national actors in research policy and research funding in the European Research Area? Which governance modes are used? Which problems of legitimacy and accountability arise because of the chosen structures and modes? The chapter thereby contributes to the analysis of new governance models emerging in the European Research Area as well as to the discussion on European governance in general.

11.2 The Changing Legal Framework and the Role of Law in the European Governance of Research

The constitutional framework of the European governance of research changed notably with the Treaty of Lisbon, continuing the constant extension of the European Union’s competences in research policy since their introduction in the Single European Act of 1987 (see for details Trute and Pilniok 2012). The Union now aims at “achieving a European Research Area in which researchers, scientific knowledge and technology circulate freely”, as Article 179 par. 1 of the Treaty on the Functioning of the European Union[1] (TFEU) states. This normative goal codifies the political concept of the European Research Area introduced by the Commission (European Commission 2000).

Additionally, with the TFEU, a normative competence order is seen in European law for the first time. Research policy is classified as a shared competence between the Union and its Member States. While a shared competence by definition can be exercised only by the Member States, who retain their competence as long as the Union does not exercise its competence, this principle varies in regard to research

[1] OJ 2008 C 115/47.

policy. As Article 4 par. 3 TFEU determines, "the Union shall have competence to carry out activities, in particular to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs". These – metaphorically speaking but mathematically inaccurate – "parallel" competences of the Union and the Member States create coordination problems that have to be addressed by the multi-level governance structures.

Despite the ambitious goal to create an ERA, the competences allocated to the European level by the TFEU within this framework of shared competences are limited. The title foresees three different types of legislative competences. In the centre of this title is still the competence to enact legislation for research funding. The regulatory structures for the framework programme as a central instrument for implementing European research policy measures and its implementing acts (specific programmes, rules of participation) are set out, thus illustrating the above-stated path-dependency in the primary law. Secondly, organisations can be set up by legislation based on Articles 185 and 187. Thirdly, Art. 182 par. 5 foresees additional legislation for realising the ERA, which for the first time empowers the EU to enact non-funding related legislation in this area. Furthermore, the explicit mission of the Union is the coordination of the Unions and the Member States' research policies according to Art. 181 TFEU (see Sect. 11.3.1 for details). The Union thus has hardly any competence for organisational rules concerning research organisations[2] and is predominantly limited to the funding of research and indirect governance, for which it has to address the Member States and their research-funding organisations.

Generally, the role of law in the governance of research is limited to the regulation of the framework conditions such as organisational norms and funding rules. It basically structures the research organisations and the funding of research (see in detail Trute 1998), while the research system basically follows a system-specific intrinsic logic (Trute 1994; Braun 2004). When aiming for stronger coordination of research policies and research funding, the governance structures are not only determined by the legal framework and its restricted competences for the Union, but also by the general conditions of research policy in a multi-level governance system (see Edler 2003: 101). The European governance of research has to take into account the heterogeneity and the complexity of national research systems, structures and policies (see e.g. McGuiness and O'Carroll 2010: 296), as they are deeply interwoven with cultural aspects. Moreover, research is a sensitive area to the Member States not only due to the national identity, but also because it is a contributor to the economic competitiveness of the respective country (Gornitzka 2005). Because research policy and law can frame only the basic conditions of the organisation and funding of research, and depend on the intrinsic logic and knowledge of the research system, uncertainty prevails about the – possibly adverse – effects of any action (Trute 1998; Edler 2003; Braun 2004).

[2] The only exception is the Joint Research Centre, which stems from the Community's engagement in nuclear research and is nowadays organised as a General-Directorate of the Commission for in-house-research (cf. Pilniok 2012). The European University Institute despite its name is subject to public international law (Kaufmann 2003).

11.3 Changing European Governance of National Research Policies

The coordination of research policies of the Member States has been one of the European ambitions from the very beginning. Even the first sign of life of a European research policy focused on this issue: The Recommendations of the Council of 1974 called for a coordination of national research policies, which was based on similar provisions in the Euratom Treaty. In this document the Council outlined the dominant motives for the coordination efforts at the European level: "eliminating unnecessary or unwarranted duplication of effort in national programmes, [...] improving the efficiency, or reducing the cost of national and Community projects by sharing of tasks or, possibly, by the concentration of resources or research teams, gradually harmonising procedures for the formulation and implementation of scientific policies within the Community".[3] Despite these ambitious aims, the Community's efforts to coordinate national research policies were not a success story (for a contemporary analysis see Brickmann 1977; in the context of the European Research Area Banchoff 2002) and were overshadowed by the Community's Framework Programmes for Research and Technological Development. Even some years after the introduction of the coordination competence in research policy in the Treaty, the Commission spoke of "dead letters of the treaty" (European Commission 1994). The Commission claimed that there were – prior to the enlargement of the European Union – "15+1" uncoordinated research policies coexisting with one another (European Commission 2000: 7). Consequently, European governance of national research policies gained more attention within the framework of the European Research Area. As a starting point for these efforts serves the explicit competence for coordination allocated to the Union in the TFEU.

11.3.1 Article 181 TFEU as a Legal Basis for Mutual Coordination

Article 181 TFEU calls for both a horizontal coordination between the research policies of the Member States and a vertical coordination between the national research policies and the European research policy in order to achieve coherence of the policies. The legal basis for the coordination of national research policies was introduced by the Single European Act in 1987 and extended by the Treaty of Maastricht in 1992. Just as with the Articles 180 and 185 TFEU, Article 181 is one of the few norms within the research chapter of the Treaty in which the Member States are explicitly mentioned. It therefore constitutes – normatively – a multi-level

[3] See Council Resolution of 14 January 1974 on the Coordination of National Policies and the Definition of Projects of Interest to the Community in the Field of Science and Technology, OJ 1974 C 7/2.

governance system in research policy. The need to coordinate research policies results from the competence structure that is established by the Treaty. While the European Community (and now the Union) gained competences in the field of research policy, this was not the result of a transfer in the competence structure. On the contrary, the Treaty of Lisbon considers the relation between national and European competences in this policy field as shared competences and adds that the right of the Member States to exercise their competences shall not be infringed (Art. 4 par. 3 TFEU). Thus, Article 181 can be understood as an answer to the growing interdependencies of the different levels of governance. A multi-level governance system with a multitude of actors, each driven by different contexts and rationalities, produces strategic interactions that have to be dealt with. This became even more the case after the objective to create a European Research Area was introduced into Article 179 par. 1 TFEU. If the European Research Area is characterised by structural complementarity (Trute and Pilniok 2012), the coordination of research policies is an essential element.

The normative goal of Article 181 par. 1 TFEU is to ensure the coherence of the research policies of the Member States and the Union. Coherence means a reasonable connection between rules, activities, programmes and actors. Meeting this goal constitutes a difference to most of the other coordination competences the TFEU contains.[4] According to the text, the scope for coordination is very broad. It can be extended to all activities in the areas of research area and technological development. The norm is binding only the Member States, not the research organisations. Thus – to further specify the text of Art. 181 TFEU – upon it calls for the coordination of the public governance of research in the Member States and in the Union. Because of this, the potential for coordination on the European level is limited in at least two ways. First, since in most Member States research funding is administered by independent agencies (see Trute 1994: 12 f.), which are at least not formally included, coordination of research funding and research programmes within the Member States is restricted. Furthermore, some of the Member States are federal states in which the competences for research policy are distributed across the levels of governance (see for a comparative analysis Watts 2008: 197).

Mechanisms for coordination are not established by Article 181 TFEU, which says only that the Commission can take up "all initiatives" necessary for the coordination. The phrase 'initiatives' in the Treaty does not include legislative measures. The scope of actions that can be based on Article 181 TFEU is, therefore, limited to non-binding measures. So until now, the success of coordination mechanisms has depended on voluntary cooperation of the Member States. This is of relevance to governance structures, since coordination promises the most likelihood of success if it draws on strategic interests of the national actors. Nevertheless, based on Article 181 TFEU each Member State is obliged to fulfil certain information duties towards the other Member States and the Commission in order to meet the knowledge requirements that are the indispensable for any coordination. This obligation corresponds to the general principle of loyal cooperation in European law (cf. on this

[4] See for example the Articles 5 par. 2, par. 3, 40, 41, 119, 141, 168 par. 2, 171, 173, 210 TFEU.

principle von Bogdandy 2007: 49 f.). Based on this broad normative framework, the Union developed a number of different mechanisms to achieve the goal given by Article 181, which shall be analysed in the following section. The most prominent set of activities is the Open Method of Coordination (Sect. 11.3.2). Additionally, the Commission uses soft law based on the coordination competence of the TFEU (Sect. 11.3.3). Furthermore, a great number of Committees working on the European level serve the purpose of coordination (Sect. 11.3.4).

11.3.2 The Open Method of Coordination in Research Policy

11.3.2.1 The Open Method of Coordination (OMC) as a European Governance Concept

The Open Method of Coordination has gained substantial interest from several disciplines since the European Council – based on the European Employment Strategy (see Ashiagbor 2005) and on the model of the OECD (Möllers 2006: 335) – introduced the OMC as a general concept in 2000 (European Council 2000: par. 38). The European Council describes the general model of the Open Method of Coordination as a process consisting of four steps. At the Union level, guidelines for common but non-binding goals are set, including timetables for their realisation at the Member State level.[5] Additionally, quantitative and qualitative indicators are created in order to benchmark the Member States. In this framework, the Member States are called upon to implement the jointly set goals within a given timeframe. Afterwards, a peer review of the results is conducted at the European level. These steps are continuously reiterated. In a broader context, these mechanisms can be seen in a number of experimental European governance arrangements, irrespective of the name (Sabel and Zeitlin 2008, 2012). Since this "ideal model" laid out by the Council has been implemented in different ways in various European policy areas, it is more accurate to speak of Open Method**s** of Coordination (Radaelli 2003: 31 ff.; Gornitzka 2005; Radulova 2007: 3 ff.; Heidenreich and Bischoff 2008). Attention in the academic literature has focused on a narrow range of policies, mostly employment policy and social policy. The implementation of the OMC in research policy has, in contrast, been far less researched (but see Gornitzka 2005; Prange and Kaiser 2005; de Elera 2006; Morano-Fodi 2009; McGuiness and O'Carroll 2010).

This article draws on the assumption that the OMC does not constitute a "new" mode of governance, as often is claimed in the relevant literature (see e.g. Hodson and Maher 2001; Regent 2003; de Burca 2003). Rather, a (theoretically limited) set of analytical modes of governance, such as competition, negotiations and networks (see in depth Benz et al. 2007), should be applied – on the OMC as well as on any

[5] Meanwhile also legally binding measures regarding the research policy based on Art. 182 par. 5 TFEU are conceivable.

other phenomenon (Benz 2007b). These modes of governance are usually intertwined, forming a complex governance regime. Thus, an analysis that reduces the OMC to a competition between the Member States (see e.g. Mehde 2005: 345 ff.) is not sufficient.

11.3.2.2 OMC in Research Policy

A closer look at the practices of the European Union that are labelled as OMC reveal a number of different activities and contain a "relatively complex web of overlapping and parallel initiatives" (McGuiness and O' Caroll 2010: 299). Four different phases and forms that are labelled as "Open Method of Coordination" should be distinguished.

Firstly, a benchmarking (see for a definition in this context de la Porte 2002: 42 f.) of national research policies was introduced. Already the first Commission communication on the ERA foresaw benchmarking as a tool for a comparative assessment of the Member States' policies. Moreover, at the beginning benchmarking was equated with the OMC. Between 2000 and 2003, serious efforts were undertaken to introduce a benchmarking. The indicators were developed in a complex process of expert and working groups, involving national research ministries, the statistical authorities at the European and the national levels, as well as researchers and research organisations. The Commission was the node of these networks and strongly pushed the benchmarking (see e.g. European Commission 2002b). Due to problems associated with the quantitative measurement of policies, as well as the continuous resistance of the Member States, the notion of benchmarking remained a short-term experiment. Nevertheless, the Directorate-General for Research has a department for monitoring national research policies and publishes key figures on science and technology every other year, but this department and its work is not integrated in the context of the OMC.

Secondly, since 2003 the core of the OMC in research policy has been the establishment of thematically-oriented working groups, organised within the framework of CREST – in the meanwhile renamed the European Research Area Council[6] – , that allow for the deliberative exchange of best practices (European Commission 2009a). The ERAC/CREST is a joint Committee of the Council and the Commission, consisting of representatives of the Member States' research ministries and chaired by the Commission's Directorate-General for Research (see in detail Pilniok 2011: 169 ff.). As opposed to other policy areas (see Jacobsson 2004: 94 f.; Heidenreich and Bischoff 2008: 516), no institutional structure was specially created for the implementation of the OMC. Instead, the coordination Committee existing since 1974 was revitalised. The activities are broadly laid out in the so-called "modus

[6] See the Resolution on the developments in the governance of the European Research Area by the Competitiveness Council, available at http://ec.europa.eu/research/era/docs/en/council-resolution-on-era-governance_26-05-10.pdf.

operandi" concerning the OMC in research policy.[7] Based on yearly cycles, the CREST chooses topics of common interest to all Member States. Topics in the recent fourth cycle included e.g. universities' research capacities and industry-led competence centres. Subsequently, working groups are established consisting of not only CREST members but also national experts. The aim of the groups is to evaluate the best practise on the topic and formulate recommendations to the CREST. To conclude, the CREST publishes reports and guidelines with recommendations to the Member States that are supposed to establish the topics of the next cycle. This is supplemented by annual "mutual learning exercises" connected to the national reform plans of the Lisbon Process (European Commission 2007a: 7).

Thirdly, peer reviews of the Member States' research policies have been conducted ever since 2005. An ad-hoc Committee set up by the CREST reviews the research policy of one Member State at a time. Since peer reviews require an evaluation from within a community of professionals that is based on their expertise and norms, the peer review is carried out by four to eight officials of the national research ministries and possibly also by representatives of the research-funding organisations. Officials of the Directorate-General Research of the European Commission participate as well. Each year two to three Member States are reviewed on a voluntary basis. The reports[8] offer the reviewed country the opportunity for stocktaking in relation to the European averages, as well as Recommendations for improving their respective research policy. The report also identifies best-practice examples from the evaluated state, which should be taken up by other Member States.

Fourthly, under the title "OMC-Net", the OMC is connected to the Framework Programme. Each year the Commission gives grants for studies, expert groups and networks of national research policy actors to – as the sub-programme is named – support the coherent development of research policies. This funding has been interpreted as a reaction of the Commission to its marginal role in the OMC process: The Commission is – as Gornitzka pointed out – restricted to a backstage role (Gornitzka 2007: 169). This is in contradiction to the current wording in Article 181 par. 2 TFEU, which assigns the leading role to the Commission.

Thus, the reality of the OMC as a "new form of executive governance" (Gornitzka 2012: 24) does not have much to do with the model outlined originally. In a governance perspective, one can draw upon an analytical distinction that was introduced by Benz (2007b) and which can be applied here to research policy. Benz distinguishes the competitive from the deliberative mode of the OMC. The competitive mode, on the one hand, is based on promoting competition between autonomous decentralised governmental actors. Comparative benchmarking induces learning processes in these actors which do not require communication between one another but yet lead to mutual adjustment motivated by the incentives of reputation and the electorates' support (Benz 2007b: 513). The deliberative

[7] See http://register.consilium.europa.eu/pdf/en/05/st01/st01201.en05.pdf (European Union 2005).

[8] The reports are available at http://ec.europa.eu/invest-in-research/coordi-nation/coordination01_en.htm (as of March 4th, 2014).

mode, on the other hand, is more cooperation-oriented: "Deliberation is aimed at finding a consensus on common objectives. Policy change is achieved by persuasion and learning from successful examples" (Benz 2007b: 511). Adequate structures to foster these learning processes are networks that facilitate the communication of best practices. Within this framework, it is clearly visible that the deliberative mode of the OMC dominates in research policy (see for a detailed analysis based on these categories Pilniok 2011: 245 ff.), as it is the case in most other policy areas as well (Benz 2007b: 513). At least from a theoretical perspective, this diminishes the feasibility of effects of the OMC influencing the national level (see in detail Benz 2007b: 522).

11.3.3 Soft Law Between Coordination and Harmonisation

As set out above, Article 181 TFEU does not allow the Union to legislate binding norms on issues of the coordination of research policies. Serving as a functional equivalent, the Commission issued several Recommendations based on Article 181 TFEU (ex-Art. 165 EC). According to Article 288 TFEU, Recommendations of the organs of the Union are one of the forms of action. Recommendations are non-binding soft law and therefore their implementation by the Member States is voluntary. Nevertheless, Recommendations usually have the characteristics of norms and are published in the legislative section of the Official Journal of the European Union. While Recommendations have for decades played an important role in other European policies (see the analysis by Senden 2004: 162 ff.), they were introduced in European research policy only upon the creation of the European Research Area. Since Article 182 par. 5 TFEU – introduced by the Treaty of Lisbon – allows legislative acts "necessary for the implementation of the European Research Area", complementing the European research funding by the Framework Programmes for the first time, there might be a shift in the coming years from non-binding Recommendations to binding legislative measures. The Recommendations would – as quite often in European law (see Senden 2004: 168) – pave the way for legislation at the European level. However, binding non-funding related European legislation would have significant institutional consequences, e.g. for the role of the European Parliament and the European Court of Justice. Furthermore – as set out above – the role of law in the governance of research is limited (Trute 1998: 208 ff.). Common to all these Recommendations is that their implementation structures resemble the OMC and institutionalise similar governance modes of implementation. This comprises especially reporting requirements by the Member States, a competition for reputation for the research (funding) organisations and installing mechanisms for exchange and mutual learning. At the same time, these Recommendations create a model for the governance of research by "framing" perspectives and agendas of both the science-policy makers and the research organisations in the Member States.

The first and most prominent Recommendation advances a European Charter for Researchers and a Code of Conduct for the Recruitment of Researchers[9] which sets standards at a European level (see also Gornitzka et al. 2007: 204; Chou 2012). The aim of such standards is the "development of an attractive, open and sustainable European labour market for researchers", as it is stated in Recital 8 of the Recommendation. In order to achieve this goal, the Member States, but also the public research organisations and the research funding organisations, are urged to implement the norms laid down in the Recommendation. From the perspective taken here, it is not the rules themselves but the modes of governance for their implementation which are of interest. The Recommendation itself refers explicitly to the Open Method of Coordination (see Nr. 12 and 13 of the Recommendation). The Member States have to report to the Commission annually about implementation measures and best practice examples. The Commission evaluates the progress of the Member States in its annual report on research policy according to Article 190 TFEU (see e.g. European Commission 2007a: 3) and reviews the Recommendation periodically. Additionally, one mode of governance used by the Commission to foster adaptation is to promote a competition based on reputation. Those research organisations that adopt the Charter are publicly named on the Commission's website. Furthermore, the implementation of the Recommendation is linked to European research funding. For example, the funding agreement concerning the grants distributed by the European Research Council obliges the host institutions to respect the European Charter for Researchers. The Charter was recently supplemented by a "partnership" of the Union and the Member States that also establishes joint goals on a European level, national implementation measures through action plans, the discussion of best practices and regular reporting and monitoring based on common indicators.

Among a Recommendation on nanotechnologies[10] and scientific information,[11] the Commission made a Recommendation for the management of intellectual property in knowledge transfer activities.[12] In the view of the Commission "public research organisations need to disseminate and to more effectively exploit publicly funded research results with a view to translating them into new products and services" (Recital 2 of the Recommendation). According to the Commission, "significant discrepancies between national regulatory frameworks, policies and practices, as well as varying standards in the management of intellectual property within public research organisations, prevent or hamper transnational knowledge

[9] Commission Recommendation of 11 March 2005 on the European Charta for Researchers and on a Code of Conduct for the Recruitment of Researchers, OJ 2005 L 75/67.

[10] Commission Recommendation of 7 February 2008 on a code of conduct for responsible nanosciences and nanotechnologies research, OJ 2008 L 116/46.

[11] Commission Recommendation of 17.7.2012 on access to and preservation of scientific information, OJ 2012 L 194/39.

[12] Commission Recommendation of 10 April 2008 on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations, OJ 2008 L 146/19.

transfer across Europe and the realisation of the European Research Area" (Recital 5 of the Recommendation). It therefore calls for standards at the European level. The Recommendation on intellectual property is closely connected to the guidelines for universities and other research institutions for improving technology transfer. Those guidelines were published not as a Recommendation but as an annex to a communication from the Commission (European Commission 2007c). Consequently, they both especially highlight the performance dimension of the research system for other societal subsystems (cf. in general on the relation between the research system and other systems Braun 2004: 65 ff.). Concerning implementation, the Recommendations refer again – although not in the same wording – to elements of the OMC. The Member States have to report regularly to the Commission on the progress of implementation. Both the Commission and the Member States are supposed to monitor implementation, e.g. through the use of indicators and the exchange of best practices. Furthermore, horizontal elements of integration are institutionalised by using the differentiated system of Committees in research policy.

11.3.4 Coordination by Committees

"Governance by committees" (Hofmann and Türk 2007: 255) is one of the key features of the European governance system in general. Committees constitute a major element of an integrated administration that intertwines the regional, national and European level (see Hofmann and Türk 2007). Since the European Research Area is a complex multi-level governance system, it is clear that Committees play a role in the integration of this sector that cannot be overstated. This is illustrated by the fact that the largest share of Committees at the European level are connected to Directorate-General Research of the European Commission (see the surveys of Gornitzka and Sverdrup 2008: 734; Larsson 2003: 16).

From a legal point of view, three types of Committees that have distinct functions and legal frameworks have to be differentiated: Comitology Committees,[13] expert groups of the Commission and Council Committees. The most prominent type of Committees – at least in terms of academic attention – are the Comitology Committees. They evolved in the 1960s as Committees of the Council when the Commission obtained administrative competences for implementing Community law (see for a detailed history e.g. Bergström 2005: 43 ff.; Blom-Hansen 2008; Schmitt von Sydow 1980: 139 ff.; Vos 1997: 210 ff.). Their task is to supervise the Commission when exercising the implementing powers. Comitology Committees have to give their opinion on a number of substantive issues defined in the respective legal acts. The Comitology Committees in research policy are involved in the

[13] Regulation (EU) No 182/2011 of the European Parliament and of the Council of 16 February 2011 laying down the rules and general principles concerning mechanisms for control by Member States of the Commission's exercise of implementing powers, OJ L 55/13; cf. for an in-depth analysis Pilniok and Westermann 2012.

influential process of concretising the vague and general framework programme into annual work programmes, calls for application and funding decisions (Lavenex 2009: 642). These opinions bind the Commission – depending on the applicable procedure – to differing extents. Already the existence of only advisory opinions by the committees points to the function of coordinating and integrating European and national perspectives on research funding. Irrespective of their formal competences, Comitology Committees are – as with any Committee at the European level – more importantly forums for public servants, facilitating the establishment of trust and the circulation of knowledge within an epistemic community (Pilniok 2011: 176 ff.).

In research policy there are Comitology Committees attached to the implementation of the Specific Programmes of the Framework Programme and SCAR, the Standing Committee on Agricultural Research (see for an in-depth analysis of the Comitology Committees in research policy Pilniok 2011: 117 ff.). The latter is an example that the changing European governance of national research policies finds expression not only in the creation of new governance structures for coordination purposes, but also in the reactivation of old structures. This Committee was founded in 1974 with the aim of coordinating the agricultural research of the Member States.[14] This arose in the context of the efforts of the Council at the beginning of the 1970s to establish foundations for a European research policy through an increase in coordination mechanisms (see Dahrendorf 1973; André 2006; Guzetti 2009). Not least because of this, the Committee saw a renaissance in the context of the introduction of the European Research Area. The focus on coordination issues constitutes a significant difference in relation to the other Comitology Committees in research policy. The interaction is thus more oriented towards information exchange and joint projects than towards decisions on proposals for implementation measures by the Commission. The SCAR surveys the structures and priorities of agricultural research in the Member States in order to create the essential preconditions for any coordination activities. This is followed by a joint analysis of research funding at the national and European level as well as by the identification of priority research topics (European Commission 2008a: 10). Based on these activities a joint planning of research funding is provided, leading to joint funding programmes and calls for proposals (European Commission 2008a: 8). Although these decisions are non-binding for the Member States and the research funding organisations, the continuous cooperation and communication brings about a mutual adjustment of the representatives of the research ministries and of the research funding organisations involved.

Another form of integration is the extensive use of expert groups by the European Commission, which is an essential part of EU administrative governance (Hofmann and Türk 2007; Pilniok 2014). According to the regulations of the Commission, expert groups are "groups comprising national and/or private-sector experts who assist the Commission in exercising its powers of initiative and in its tasks of monitoring and coordination or cooperation with the Member States" (European

[14] Regulation (EEC) No 1728/74 of the Council of 27 June 1974 on the coordination of agricultural research, OJ L 182/1.

Commission 2005: 3). Unlike Comitology Committees, they are not explicitly called for in Union law. Nonetheless, it is accepted in the legal literature that the Commission has the competence to establish expert groups for its assistance, provided this is done within the budget available to the Commission (Hilf 1982: 115 f.; Schmitt von Sydow 1980: 125 f.).

Within this flexible system new forms of governance structures have emerged across the different levels of the European Research Area. An interesting example of the use of expert groups as an instrument for the European governance of research is the European Strategy Forum for Research Infrastructures (ESFRI). In the process of defining the concept of the European Research Area, the European Commission soon gave attention to the research infrastructures (European Commission 2001). It is obvious that – especially large-scale – research infrastructures are a prime example of the advantages of a division of labour within the European Research Area as a means to maximise the efficient use of public funds. To facilitate the cooperation in this area, the Commission set up the ESFRI in 2002, formally as an expert group of the Commission. The members of the ESFRI are representatives ("senior policy officials") of the Member States' research ministries and of DG Research of the Commission. The ESFRI has developed a complex organisational structure, with a number of working groups under its umbrella.[15] The activities of the ESFRI are connected with the funding conducted through the Framework Programme for research infrastructures: The competition for European funding from the Framework Programme is predominantly restricted to those research infrastructure projects chosen by the ESFRI (see European Commission 2010). These activities led also to new legislation on research infrastructures, which created a special framework for legal entities established by several Member States for the joint operation of research infrastructures.[16]

11.3.5 The Changing Governance of Research Policies and Its Consequences

European governance of the coordination of national research policies is mainly based on the deliberation in Committees as well as on soft law and its linkage with research funding. This marks an important difference towards the model of the OMC that stresses – at least in theory – competition as the dominating mode of governance. Therefore, dense and overlapping horizontal and vertical governance structures have been established or – e.g. as the Standing Committee of Agricultural Research – revitalised after a long moratorium. The Commission plays a major role in initiating these forums and acting as a network manager (see on the notion of the Commission's task of network management Metcalfe 1996).

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[15] See the Procedural guidelines of ESFRI (2008).

[16] Council Regulation (EC) No 723/2009 of 25 June 2009 on the Community legal framework for a European Research Infrastructure Consortium, OJ L 206/1.

Through the activities of the European Union, especially the Recommendations of the Commission, and within the working groups on the different themes of the OMC, a European model for the national governance of research has been outlined. The model clearly reflects a specific tradition of European research funding that emphasises the functional dependence between research and economy. The practical effects of the OMC are not clearly visible. Their evaluation is a difficult methodological problem and beyond the scope of legal research. It is, nonetheless, ironic that the main argument against benchmarking – the difficulties in measuring successful policies – is true for the OMC itself (see the incisive question by McGuiness and O'Caroll 2010: 307 "How quantifiable is success?"). From a theoretical perspective, it has been convincingly argued that deliberation due to lacking incentives diminishes possible outcomes of coordination in a two-level perspective (Benz 2007b). In any event, the success of the different layers of the OMC in research policy can not be measured only in terms of whether the Union met its political goals connected to the process. However, from the perspective of the relevant actors within ERAC, the Member States' research ministries and the European Commission apparently have fulfilled their duty, with or without providing the success the OMC initially promised. The use of the OMC as an overall concept quietly faded out although a number of elements persists in the work of ERAC. In any event, the formation of a common cognitive framework and the development of epistemic communities that accompany the governance structures of the coordination of the national research policies surely are lasting effects.

11.3.6 Problems of Accountability and Legitimacy

The multi-level governance system in Europe raises challenges for traditional modes of legitimacy and accountability. A conceptual approach that shall be drawn upon for this analysis was introduced by Bovens (2007a, b) and elaborated in the European context by Curtin (2009). Accountability is defined by Bovens as "a relationship between an actor and a forum, in which the actor has an obligation to explain and to justify his or her conduct, the forum can pose questions and pass judgement, and the actor may face consequences" (Bovens 2007b: 450). In this concept, accountability has several dimensions, such as political, judicial, administrative, professional and social accountability (see in detail Bovens 2007b: 455 ff.). Prerequisite for any form of accountability is the provision of a sufficient degree of transparency. The intransparency of the OMC is much criticised (see e.g. Benz 2007b: 515). However, the situation is different with regard to the OMC in research policy, since the ERAC/CREST, as opposed to other policy areas with specifically institutionalised Committees, oversees the OMC. The documents of the ERAC/CREST are – though only recently – provided by the Secretary-General of the Council, supplemented by a website operated by the Commission and dedicated to the OMC in research policy. Accountability towards the European Parliament has been increased by the new reporting requirements enshrined in Article 181 par. 2

TFEU, even though these requirements are only applicable for the Commission. The accountability of the OMC process towards the national parliaments has especially been the subject of critical appraisal (see e.g. Szyszczak 2006: 495). However, also the advantages of increased mutual control through peers, e.g. through the peer review of national research policies, have to be taken into account. Although the national parliaments are not visibly involved in the OMC process, accountability might be enhanced due to the knowledge and indicators on performance and problems delivered by the OMC to the national parliaments, which allows the Member States' governments to be held accountable. The accountability might as well be enhanced due to the knowledge and the indication of the performance and problems delivered by the OMC to the parliaments that allows to hold the national governments accountable (see for this line of argument Sabel and Zeitlin 2008: 277 f.; Trute et al. 2008: 176). Nevertheless, since the relevant Committees and working groups search for consensus in a non-public discourse, problems arise in the deliberative mode (Benz 2007b: 513).

European soft law does not evoke problems of accountability to the same extent since it is incorporated in the basis of the legitimacy of the Commission (on the legitimacy of the Commission Trute 2006: Rn. 102 ff.). Still, questions arise concerning the transparency and accountability of the Committees established for the implementation processes. These questions refer to the multidimensional problems concerning the Committees' transparency and accountability. The Committees have to be differentiated according to types of Committees and their function within the European governance system. However, this is beyond the scope of this study and cannot be dealt with in detail here (see in-depth Pilniok 2011).

11.4 The Changing European Governance of National Research Funding

If the European Research Area is supposed to be an integrated system and not just an additional layer on top of the Member States' policies, not only the Member States' research policies but also – and even more importantly – the research-funding programmes in the Member States have to be more intensively integrated. The importance of this element of a European Research Area is continuously stressed. This includes different types of integration. The first type is the mutual adjustment of thematic-oriented funding programmes. Such an approach is chosen by the Union's framework for the joint programming of research funding, which includes a structured approach.[17] The central innovation in contrast to the traditional model of European research funding is the second type, the institutionalisation of new hybrid research funding organisations that connect the European and the national level.

[17] See European Commission 2009b.

They are an important part of the emerging 'European research administrative space' (Langfeldt et al. 2012: 90). In the following section the focus lies on two different lines of action with varying legal conceptions and densities of cooperation that have evolved in the last 10 years: the Era-Net scheme as part of the Framework Programme (Sect. 11.4.1) and governance structures based on Article 185 TFEU for the joint implementation of research-funding programmes of several Member States (Sect. 11.4.2).

11.4.1 Era-Net Scheme: Coordination Through Competition and Cooperation

The coordination of national research-funding programmes lies at the centre of the proposal the Commission made for the creation of a European Research Area (European Commission 2000, 2007b). The Sixth Framework Programme introduced the Era-Net scheme, addressing the national research-funding organisations for the first time in the history of European research funding. With several alterations this scheme is continued in the Seventh and Eighth Framework Programme. Since 2002, more than 80 networks of research funding organisations have been funded by the European Union, each of them devoted to a specific scientific discipline or scientific topic (see for the following analysis Pilniok 2007; Pilniok 2011: 361 ff.). These measures exemplify not only a changing relationship between the European and national level of research funding, but also new forms of governance introduced by the European Union.

11.4.1.1 European Competition for Networks of Research Funding Organisations

The consequence of the integration of the Era-Net scheme into the Framework Programme was to open up a competition between national research funding organisations due to the fact that the Financial Regulation of the Union[18] foresees a competitive procedure for European grants. Since there are budgetary alternatives, one can assume that a competitive governance structure was chosen by the Union – and especially the Commission – because of its advantages in a multi-level system. The rules of the competition for European grants are structured by the Framework Programme, the respective Specific Programme and – with regard to the most important criteria – the implementing work programme issued by the Commission. According to the work programme, the Commission issues calls for proposals. While these calls were originally completely open to any scientific subject,

[18] Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002, OJ 2012 L 298/1.

in the Seventh Framework Programme disciplines and topics are more specifically addressed. Applications require the participation of at least three research funding organisations from different Member States. The selection of applications is based, inter alia, on the creation of adequate internal governance structures by the funding organisations as well as on a long-term commitment to cooperation. This governance arrangement forces the funding organisations into intensive cooperation even when just considering an application. The self-coordination process requires of the funding organisations to possess knowledge about the funding structures in the other Member States. The institutionalisation of competition mobilises the strategic interests and the decentralised knowledge of the funding organisations. The competition between the consortia of the Member States' research funding organisations is based on incentives, not coercion. It allows designing a cooperative initiative that adequately respects the heterogeneity of funding structures in the Member States as well as of the different approaches to scientific disciplines and topics. In this respect, the competition fosters innovative solutions while simultaneously allowing differentiated integration.

11.4.1.2 Vertical and Horizontal Governance Structures Among the Commission and the Research Funding Organisations

The vertical governance structure between the Commission and the consortium of the participating research-funding organisations is determined by an agreement whose conclusion is required by the Financial Regulation. For all grants within the Framework Programme the Commission uses a model agreement – with different variants for specific funding lines. The agreement fixes the working programme and the deliverables, on the one hand, and the Union's financial contribution, on the other. The most important role in the agreement is the coordinator of the consortium, who is responsible for the obligations towards the Commission. These obligations include reporting requirements that serve the Commission not only for control purposes but also for generating knowledge. Additionally, extensive financial control mechanisms are established by the model agreement, as well as unilateral rights of the Commission.

The horizontal governance structure between the participating research-funding organisations is in most cases – as recommended but not required by the Commission – governed by a consortium agreement in which the internal decision-making structure and the distribution of work packages within the consortium are laid out. Consequently, the consortia exhibit characteristics of an organisation combined with features of a more loosely coupled network. Based on the equal participation of all funding organisations involved, internal governance is dominated by negotiations within the institutional structure laid out by the consortium agreement. In sum, this creates a complex network of contracts administered by the Commission and integrating a huge number of research-funding organisations across Europe. As a consequence to this diversity, the Commission installed mechanisms for monitoring of the networks and their mutual exchange.

11.4.1.3 Forms of Joint Research Funding Through Era-Nets

The Commission and the consortia of research-funding organisations typically agree on procedural integration measures that follow a step-by-step approach. Initially, the cooperation focuses on stocktaking exercises that evaluate the heterogeneity of research funding, its organisation and its procedures in the specific scientific discipline being addressed. It is not only knowledge about the situation in the other Member States but also mutual trust that has to be generated. This is supposed to be complemented by the exchange of best practises of research funding and leads to extensive self-descriptions by all disciplines and Member States, which are of high value to the Commission as well as to the scientific community at large. Finally, all networks of research-funding organisations are urged to implement a joint research programme, which is in the meantime even a funding requirement. Therefore, a range of models has evolved whose main differences consist of the extent to which the financial aspects are handed over to the consortium. Through the co-funding of these joint programmes the Commission sets additional incentives for establishing joint research-funding programmes that include a "common pot". This "common pot" is used for funding, irrespective of the nationality of the successful applicants and thus creates a de-nationalisation of research-funding and a European-wide competition.

11.4.2 Governance Structures Based on Article 185 TFEU

Article 185 TFEU foresees that the Union may participate in research and development programmes undertaken by several Member States. As remarked in the Articles 180 and 181 TFEU, the Member States are explicitly mentioned in the Treaty, which therefore forms a part of the constitutional norms of the European Research Area. Although introduced in the Single European Act in 1987, it has not been referred up to 2002. In the context of the concept of the European Research Area, the use of this competence first revealed itself. In the context of the Sixth Framework Programme, the first measure on the basis of Article 185 TFEU was taken. This example revealed the presuppositions and the problems of the integration of national and European research funding. In the meantime, the legal basis was used for institutionalising five initiatives, which are continued under the Horizon 2020 framework programme.

11.4.2.1 Normative Framework: Article 185 TFEU and Implementing Decisions

Article 185 TFEU addresses several Member States and therefore constitutes an instrument of variable geometry. Integration in this area can be intensified without requiring the consent of *all* Member States. At the same time, it is in the interest of the Union to incorporate a significant number of Member States since only then substantial effects can be expected. The norm aims at integrating the research-funding programmes of several Member States. Thus, the scope is limited to existing programmes. Research-funding programmes are understood by the Commission as "clearly defined activities or measures (whether or not formally called "programmes") on a specific theme or in a specific area, with an earmarked budget and implemented over a set period following clear procedures" (European Commission 2002a: 5). These research-funding programmes have to be publicly financed, either by the Member States or publicly financed research-funding agencies in the Member States. The way of participation of the Union is mainly left open by Article 185 TFEU; nevertheless, financial participation is the key element. The article allows also the creation of common organisational structures by the Union and participating Member States. Decisions on the basis of Article 185 TFEU are taken through the ordinary legislative procedure according to the Articles 188 par. 2 and 289 TFEU. This constitutes a strong position for the European Commission given its monopoly on initiative, which is limited by both the necessary consent of the participating Member States and the requirement of being laid out in the Framework Programme. Unlike the Era-Net scheme, competitive elements can be found only in the Commission's exertion of its right of initiative, which is based on the previous experiences of Member States cooperating in a specific field of research funding. The ordinary legislative procedure requires time-consuming political bargaining processes and provides less flexibility in the course of implementation, as compared to the Era-Net scheme. The substantially higher transaction costs therefore limit this formalised course of integration to only a small number of fields.

Within this normative scheme, the Framework Programmes contain a general decision of the Union to participate in joint research-funding programmes with several Member States. The Framework Programme outlines common criteria for participation, while the Specific Programmes for the implementation of the Framework Programme specifies the particular scientific fields that are envisaged for a joint Programme of several Member States. The decisions taken so far contain similar elements and follow a common structure: The decision itself lays down the conditions for the financial participation of the Union concerning the joint research-funding programme. Annex I of each decision describes this research-funding programme in general terms and prescribes some basic rules for the procedures. Annex II of each decision adopts the internal decision-making structure of the "dedicated implementation structures", which have to be established by the participating Member State in order to administer the funds. The decisions are supplemented by general and yearly agreements between the Commission and these dedicated implementation structures. Thus, normatively complex governance structures are emerging along both the vertical and horizontal dimension.

11.4.2.2 Vertical and Horizontal Governance Structures

From a vertical perspective, the relationship between the Commission and the dedicated implementation structure, which is established by the participating Member States according to civil law rules, is mainly focused on financial issues.

The decisions define several conditions for the financial contribution of the Union. These are, inter alia, the establishment of a joint research-funding programme as laid out in the decisions, the establishment of an “appropriate and efficient governance model” (see Article 2c of the Decision 742/2008/EC),[19] and formal commitments of the Member States to contribute in sum the same amount as the Union. The strong financial focus of the Council decisions is also underlined by the extensive rules – stemming from the financial regulation – to protect the financial interests of the Union. These “safeguards” for the Union’s funding are a response to the problems that the first initiative based on Article 185 TFEU revealed, especially the reluctance of the participating Member States to follow-through on their planned contributions (see in detail European Commission 2008b).

The dedicated implementation structures have to be organised according to available corporate law. Consequently, they are governed by both public and private law. In the emerging field of European corporate law, the European Economic Interest Grouping (EEIG) is one legal structure that was introduced to facilitate the cooperation of business actors in the single market. For its use by the Member States and governmental actors, EEIGs have the disadvantage of unlimited liability for all participating parties, which is, for example, forbidden in German public law for governmental actors. Nevertheless, one can find EEIGs among the dedicated implementation structures in several forms of non-profit organisations, according to the laws of different Member States. This individualised construction allows for a description of the internal decision-making structures on only a very general level: Usually, all implementation structures foresee a general assembly that consists of representatives from all participating research-funding organisations. The main implementation tasks are entrusted to an executive board, which is supported by a secretariat. Finally, all structures contain advisory bodies to consult the relevant scientific community of the specific field that is funded.

[19] Decision No. 1209/2003/EC of the European Parliament and of the Council of 16 June 2003 on Community participation in a research and development programme aimed at developing new clinical interventions to combat HIV/AIDS, malaria and tuberculosis through a long-term partnership between Europe and developing countries, undertaken by several member states, OJ 2003 L 169/1; Decision No. 742/2008/EC of the European Parliament and of the Council of 9 July 2008 on the Community’s participation in a research and development programme undertaken by several Member States aimed at enhancing the quality of life of older people through the use of new information and communication technologies, OJ 2008 L 201/49; Decision No. 743/2008/EC of the European Parliament and the Council of 9 July 2008 on the Community’s participation in a research and development programme undertaken by several Member States aimed at supporting research and development performing small and medium-sized enterprises, OJ 2008 L 201/25; Decision No. 912/2009/EC of the European Parliament and of the Council on the participation by the Community in a European metrology research and development programme undertaken by several Member States, OJ 2009 L 257/12; Decision No. 862/2010/EU of the European Parliament and of the Council of 22 September 2010 on the participation of the Union in a Joint Baltic Sea Research Programme undertaken by several Member States, OJ 2010 L 256/1.

11.4.2.3 Joint Research Funding Among Dedicated Implementation Structures and National Research Funding Organisations

If one adds up the funding of existing joint research programmes, a total amount of several billion euros, shared by the Union and the participating Member States, is distributed by these new actors. The central element of the joint research funding is the annual working programme that defines the planned calls for proposals and sets a timetable for the funding activities (see in detail for the following Pilniok 2011: 334 ff.). This expresses the formative influence of the Union's Framework Programme on these initiatives driven by the Member States. The basic elements of the funding programmes are enshrined in the Annex to the Council's decision. The development of and the decision on the working programme follow the respective decision-making structure of the dedicated implementation structure. Generally speaking, the decision on the working programme, as one of the most important decisions when creating a new funding programme, is the right of the general assemblies, in which all participating Member States are represented. The dedicated implementation structure has to submit the annual working programme to the Commission as a precondition to concluding the annual financial agreement. The Commission is thus assigned to a strong role with hierarchical elements.

The common denominator is the centralisation of the selection procedures by the dedicated implementation structure, while the administration of the selected research projects is left to the participating national research organisations. The basic principles of the selection procedures are agreed upon in the respective Council's decision, but leeway is left to the dedicated implementation structures to create the specific procedures, guided by the principles of equal treatment and transparency. The criteria for the awarding of grants are prescribed by the Council's decisions as well, resembling the respective criteria in the Framework Programme and the Specific Programmes. Scientific excellence is stressed as the primary criterion. The proposals for research projects to be funded have to be reviewed by independent experts. Based on these reviews, the dedicated implementation structure – as a rule, their general assemblies – creates a ranked list of proposals, which is binding on the allocation of funding both from the Union's contribution and from national budgets earmarked for the respective joint programme. Difficulties arise regarding the question of whether there is judicial supervision of these funding decisions. Since Article 263 par. 4 TFEU comprises only the organs foreseen in the TFEU, no legal control by the European Court of First Instance is provided for. Judicial supervision is restricted to the measures foreseen in the Member State hosting the dedicated implementation structures according to the respective civil procedure law.

11.4.3 Changing the European Governance of Research Funding and Its Consequences

Recent developments in the European governance of research can be characterised as an institutional differentiation in research funding. It is no longer the "standard procedure" of the Framework Programme that is representative of European research policy. Just as the European Research Council (see the contribution of Groß and Karaalp in this volume), the networks that connect European and national research funding are institutional novelties. From the perspective of the researchers and the research organisations, the changing landscape of research funding is relevant due to shifting relation between institutional and competitive funding (see Enders, Kehm and Schimank, in this volume). The new European initiatives lead to a higher diversity of available funds. The role of the European level is modified towards creating complex horizontal and vertical governance structures. The rules governing the European budget, which limit the scope for design through detailed rules, are decisive for these governance structures.

This has consequences for research funding in the Member States. The national research funding organisations are involved in complex and overlapping networks with their European partner organisations. The distribution of national money in these networks follows European standards and procedures. Since reflecting on best practises in research funding and reaching mutual agreement on common procedures is one of the key features of these networks, it is likely that effects on "purely" national and regional research-funding programmes can be expected. This is all the more likely as the integration of the personnel of the funding organisations will at least to a certain extent "Europeanise" their cognitive patterns towards research and its funding.

11.4.4 Problems of Accountability and Legitimacy

The different forms of joint research funding evoke also questions of accountability and legitimacy. As compared to the governance of coordination of the national research policies outlined above, this is even more the case here given that binding decisions on the allocation of funds are taken vis-à-vis the researchers. It seems questionable whether the activities of these governance structures are adequately transparent.

Their financial accountability towards the Commission is – due to the financial regulation of the European Union – strongly accentuated. In contrast, judicial supervision of the funding decisions taken on a transnational level is mostly absent. The research funding both by the ERA-Net consortia of national research funding organisations and the governance structures created on the basis of Article 185 TFEU either lack judicial supervision or are at least depending on the national judiciary system (see in detail Pilniok 2011). At the same time, the accountability of the consortia and networks towards the parliaments seems unclear. The governance structures based on Article 185 TFEU establish reporting requirements via the Commission towards the European Parliament, but not towards the national level of the involved Member States. This problem is even more apparent for the ERA-Nets distributing national research funds. To what account peer accountability within the networks of research-funding organisations can compensate for this lack remains an open question.

11.5 Conclusions

Seen from a governance perspective one can clearly distinguish different phases of European integration in research policy. The first phase was based on a separate layer of European research funding, characterised by the dominance of the direct implementation by the European Commission. The second phase started with the advent of the European Research Area in 2000. The numerous initiatives created a drastically increased institutional complexity, which constituted a ‘third layer’ between the European and the national research policy and funding. Due to heterogeneity and the rapidly changing fields of research, the European modes of governance are based on reflexivity and on the learning aptitude of the governance system. This is expressed by the high number of evaluations and reviews by expert groups that are integrated in European research policy. Without a doubt, research policy is at the forefront of “innovative governance in the European Union” (Tömmel 2009). The governance structures presented here clearly illustrate this point. One can see effects of the changing European governance of research both on the Member States’ research policies (for examples related to the mobility of researchers see McGuiness and O’Carroll 2010: 308) and the research funding in the Member States. The more important is an improved balance of these modes of governance with the quest for accountability and legitimacy.

As pointed out, new (legally co-structured) institutionalized forms of governance emerged in the European governance of research, creating new institutions for horizontal and vertical links between the European and national actors. These are mostly characterised by flexible integration in the mode of ‘variable geometry’ and based on positive incentives. However, also binding European legislation and the Framework Programmes, including the implementing acts, have increased in importance in the field of research policy, as shown by the examples of the “scientific visa package”[20] or the creation of a legal framework for the European research infrastructure consortia. The changed Union competences and perceived deficits of the progress with an ‘internal market for research’ currently lead to political discussions about an increased use of non-funding legislative measures. It might well be that a third phase can be witnessed soon, which would lead to significant institutional consequences for the European governance of research.

[20] See Council directive 2005/71/EC of 12 October 2005 on a specific procedure for admitting third-country nationals for the purpose of scientific research, OJ 2005 L 289/15.

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Chapter 12
Technology Transfer: The Change of European Governance of Research from a Private Law Perspective

Christine Godt

12.1 Introduction

From a private law's perspective, the most significant change in research governance structures stems from technology transfer based on patents and licensing. It was officially made the Third Mission of universities, beside research and teaching, in all European countries by the end of the 1990s. In Germany, it was enacted by way of abolishing the privilege of professors to file patents autonomously out of their own right in 1998 (§ 2 Abs. 7 German Federal Law on Higher Education "Hochschulrahmengesetz" (HRG), BGBl I of 20.8.1998, p. 2190). At its centre is the broad commodification of academic innovations via patenting, assigned as property to the institutions and administered by them. The law reversed the traditional assignment to professors. The idea is to improve the overall competitiveness of knowledge-based economies by a property-protected influx of innovations. The consequence are novel contractual arrangements between academia and industry, ranging from the single acquisition of knowledge to long-term collaborations.[1] In this regard, modern technology transfer differs from previous forms of institutional arrangements which relied on more personal forms of "spill overs", e.g. geographical clustering in technology parks, transfer of personnel/employees, and managerial communication policies. Whereas the term "spill over" is used for incidental forms of knowledge transfers, "technology transfer" is meant to be intentional, specific and proprietary. In this sense, old and new forms complement each other. However, universities continue to struggle with the Third Mission. Not only has the amount of necessary

[1] In Germany, the legal basis is the novel assignment of academic inventions to the University in 2002. Before this time, inventions were attributed to the individual professor, former § 42 German ArbNErfG).

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contractual coordination risen (see e.g. DESCA[2] [infra]), but also the open and contentious question of funding and organisation of technology transfer offices in Germany. Organisational structures have ranged from intra-university departments to outsourced entities, and man closed or merged their operations until then. More important, technology transfer has challenged academic values and the very self-understanding of academic institutions as "knowledge creating" entities (in contrast to "profit generating" centres). These tensions became crystalized in a conflict between the League of European Research Universities (LERU) and the European Commission. LERU criticised the Intellectual Property (IP) policy of the Innovative Medicines Initiative (IMI) and the access policy of the European Commission as depriving the universities of their property (IMI 2010; LERU 2010).[3]

This article explores the concept and the persistent tensions with regard to technology transfer as *the* most important private-law-related change in research governance. First, the article will briefly track the historic development of technology transfer. Second, it will explore current structures on the European and on the national level, which gave rise to subsequent conflicts like the LERU-Commission's dispute, and will shed some more light on the situation in Germany. Third, it will subsequently discuss legal problems with regard to technology transfer before developing a modern concept of the role of public research institutions in technology transfer in Sect. 12.4. Some conclusions finalise the exercise in Sect. 12.5.

12.2 History and Concept of Technology Transfer

Technology transfer, in its wider sense, has always been an issue of European R&D policy, not only since an explicit R&D chapter has been introduced into the European Treaty in 1986. In the early days, European policy, focused on fostering industrial collaborations, aimed at advantages in scale. Its paradigm was on access ("freedom of competition") and sharing knowledge ("dissemination of information"). Influenced by the US experiences with the "Bayh-Dole Act", policy makers shifted towards property-secured technology transfer. The transition from the fourth to the fifth Framework Programme (FP) marked the watershed in technology transfer. For the first time, the participation rules allowed to grant exclusive licenses for knowledge arising from research funded under the fifth FP (Art. 30 sec. 1, 2 sentence EC-Reg. No 996/1999, OJ *L 122 of 12.5.1999*, *pp. 9–23* (European Commission 1999; Godt 2007: 165, 215)).

[2] **DE**velopment of a **S**implified **C**onsortium **A**greement for FP7, developed by a group of stakeholders of the European Framework Programme, ANRT (www.anrt.asso.fr), the German CA-Team (represented by Helmholtz – www.helmholtz.de and KoWi – www.kowi.de), Fraunhofer (www.fraunhofer.de), EARTO (www.earto.eu), Eurochambres (www.eurochambres.be), and UNITE (www.unite.be). It aims at a "reliable frame of reference seeking to balance the interests of all of the main participant categories in FP research projects: large and small firms, universities, public research institutes and RTOs".

[3] http://www.leru.org/files/publications/LERU_Letter_on_IMI_2010_09_02.pdf.

This philosophy was nourished by the modern “Mode 2”-paradigm, resp. the “Triple Helix” innovation theory. This theory suggests that property could help to transfer academic knowledge into the product development process. But unless academia transfers exclusive rights, industry will not invest in development. This idea demarks a departure from the linear innovation model which puts idle basic research at the beginning of the time line, applied research in the middle where practical applications are explored and industrial development at the other end of the time line when industry converts the idea into a product.

Since then, the impact of technology transfer has been much debated. At the core of discussions is the “entrepreneurial university”(Levie 1999; Gibb and Hannon 2006; Rothaermel et al. 2007). Whereas university managers and politicians have broadly embraced the idea as a means of defending the prosperity of the Western industrialised states against upcoming nations of the East (e.g. the Excellency Award of the German Research Foundation to the Technical University of Munich for its concept “TUM. The Entrepreneurial University” (TUM 2003–2011; Mogge-Stubbe 2006), sociologists like Richard Münch are much more skeptical (Münch 2007: 148). The latter fear that the specificities of public research will be lost. Universities could mutate to “workbenches” for industry and lose their independency. The “commercialisation” of research would lead to a neglect of research areas unappealing to industry (areas, where profits are not to be expected).

The European Commission seems to be aware of this policy conflict. In its Communication COM (2008) 1329 of 10.4.2008 (p. 6) it states as principle 9: “While proactive IP/KT policy may generate additional revenues for the public research organisation, this should not be considered the prime objective.”(Commission of the European Communities 2008). In a very similar wording, the US National Research Council found in a study published in September 2010 that overall technology transfer might be beneficial; however, adjustments are due. Two conclusions stand out: Firstly, the idea that technology transfer offices (TTOs) have to finance themselves should be abandoned, and secondly, more governmental oversight is needed to secure public accountability (Merrill and Mazza 2010).[4]

Ultimately, the saldo of technology transfer seems to be mixed and differentiated (D’Este and Perkmann 2010). From a macro-economic point of view, it looks as if academic institutions contribute largely to an innovative technology development. Block and Keller find that two thirds of the top 100 innovations of the year have come from partnerships involving business and government, including federal labs and federally-funded university research (Block and Keller 2008). Young scientists profit from the development. They are being offered new opportunities to work in a research-close setting, and for some these activities serve as a spring board. Universities seem to profit since technology transfer offers new options for (long term) collaborations (D’Este and Perkmann 2010). On the other hand, academic institutions might to be deprived of steering their own research foci and sometimes put future options to pursue in-house research at risk. Whereas in the beginning the

[4] “[T]he likelihood of success is small, the probability of disappointed expectations high, and the risk of distorting and narrowing dissemination efforts is great” (InsideHigherEd 2010).

predominant concern was about delayed publications, skeptical considerations have shifted towards questions of access and the process of research as a whole. Researchers opt for research areas where they expect institutional support ("mainstream") and are discouraged from undertaking unconventional research. Contractual arrangements substitute what has been known as public domain. Proprietary arrangements require scientists to ask colleagues (and competitors) for permission to do research, and make newcomers hesitate to do research in fields which are perceived to be "taken" (or where patent thickets make research risky), thus thinning out competent colleagues who evaluate results.

12.3 Concepts of Technology Transfer

12.3.1 European Level

For European research policy, industrial politics have played a central role since the beginning. Art. 179 sec. 1. Treaty on the Functioning of the European Union (TFEU), states that "The Union shall have the objective of strengthening its scientific basis by achieving a European research area (…) and encouraging it to become more competitive, including its industry (…)".[5] In this regard, industrial applicability has been an integral objective of European research policy, requesting the participation of an industrial partner in most of the programmes. It has only become complemented by setting up the (basic-research oriented) European Research Council since 2006 (cf. Laredo, Groß and Karaalp in this volume). The following section focuses on the main instrument of European research funding, the Research Framework Programme (FP) (Sect. 12.3.1.1), collaborative attempts of European academic institutions to cope with the new task (Sect. 12.3.1.2), and novel collaborative instruments with shared funding between the European Union and industry, the Joint Technology Initiative (Sect. 12.3.1.3).

12.3.1.1 The Multiannual Research Framework

The most important instrument of the European research policy is the multiannual Framework Programme (FP), Art. 182 TFEU. It prescribes tenders to specific topics within specific programmes and allocates funds. In its various specific actions, it has always fostered collaborative research consortia. Not only did the European Union make the inclusion of industry a prerequisite for most of its

[5] The Wording of the Amsterdam Treaty (ECT, effective until 31. Dec. 2009) was more outspoken about its industrial objective: It read in its Art. 163 ECT: "The Community shall have the objective of strengthening the scientific *and technological bases of Community industry* and encouraging it to become more competitive at international level(…)" Italics, added by the author, indicate the differences between the versions of the Amsterdam Treaty and of the Lisbon Treaty).

actions, but it also shaped the proprietary set-up in these consortia by participation rules (issued as directly applicable regulation under Art. 183 TFEU (European Union 2008)). The rules of participation for the seventh Framework Programme (2007–2013) were issued as Reg. 1906/2006 (European Union 2006: 1), the rules of participation for the Programme "Horizon 2020" are about to be published[6] [Stand 30.1.2014].

As a default rule, intellectual property belongs to those participants who generate the invention (Art. 39 Reg. 1906/2006; Art. 41 Horizon2020-PR). Patenting is expected,[7] so is commercial use (covering exploitation via exclusive licensing and transfer).[8] One of the central objectives was the regulation of differences with regard to joint (resp. common) property of results developed under the project (and each co-owner's right to exploit the property share). Where no agreement was made, each joint owner is entitled to sub-license after prior notice, granting fair and reasonable compensation (Art. 40 sec. 2 Reg. 1906/2006; Art. 41 sec. 2 Horizon2020-PR).[9] In addition, access rights to project results and access to knowledge, which has been brought into the project, are stipulated (Art. 50 Reg. 1906/2006; more elaborated in Art. 45 ff Horizon2020-PR). Under FP7, project partners enjoyed the right to access either under fair and reasonable conditions or royalty free, Art. 50 sec. 1 Reg. 1906/2006. This right can be further qualified (e.g. "for research purposes/royalty free"). The right to use, as the standard FP7-rule, is limited to one year after the end of the project (Art. 50 sec. 4 Reg. 1906/2006). Horizon2020-PR differentiate more clearly between royalty-free access rights for implementation (Art. 47 Horizon2020-PR) and fair and reasonable conditions with regard to access rights for exploitation (Art. 48 sec. 2 Horizon2020-PR).

12.3.1.2 Model Contracts: EU Consortia Agreements (DESCA-Model[10])

The remaining flexibilities (esp. in the participation rules RF5-RF6) gave rise to a great variety of possibilities. Round about 57 varieties were counted, 17 different model contracts emerged until 2006 (all documented on IPR Helpdesk n.d.). This complexity was soon perceived too costly, too time-consuming, too complicated. Despite the sentiment that "one size does not fit all" the claim for one frame model

[6] http://ec.europa.eu/research/participants/portal/doc/call/h2020/common/1587751-h2020-rules-participation_en.pdf.

[7] Art. 44 sec. 1 Reg. 1906/2006: "Where foreground is capable of industrial or commercial application, its owner shall provide for its adequate and effective protection (…)".

[8] For the historic development with regard to commercial use forms see Godt 2006.

[9] Since 2005, this rule corresponds to German case law, at least with regard to common property (not joint property). The BGH clarified in *Gummielastische Masse II* (*BGHZ 162*, *342*) that partners have no financial claims to compensation when partners exploit common property unless they negotiated so. This legal situation corresponds to the one in common law countries (BGH 2005).

[10] DEvelopment of a Simplified Consortium Agreement for FP7.

contract became louder. The UK Lambert Tool Kit[11] (model for EU-CREST-Cross Border Decision Guide) took the lead claiming a "holistic approach", and voiced as a principle "at least a non-exclusive license".

Its Consortium 1-Model Treaty granted: (1) each of the others a non-exclusive royalty-free license to use its results for the project, (2) each of the others a non-exclusive royalty-free license to use its results for any other purpose, (3) it stipulates that any member of the Consortium may exploit any of the results. The models 2 and 3 gave more rights to industry.[12]

The Lambert Kit became the model of the European consolidation which is now known as the "DESCA-Model". It was made to become the single reference for FP 7 DESCA is a partnership of then five associations representing European universities, public and private research organisations, and industry.[13] The DESCA-Model is used by ca. 80 % of all FP7-Consortia. E.g. at the German Helmholtz-Institutes, it is used as the default contract for further negotiations.[14] Its goal is to find common ground which respects the interests of academia and industry alike. It cooperates with an initiative called "Responsible Partnering" (2005). Three elements qualify the DESCA-Model: (1) With regard to joint ownership, partners have the right to license (unless otherwise convened) after prior notice of 45 days and subject to fair and reasonable compensation. An alternative option is to grant the right to use, however *without* prior informed consent (PIC), information, compensation (No. 8.1 DESCA-Model, option 1 and 2). (2) Partners are allowed to transfer foreground, with (or without) PIC to a limited list of affiliated third parties (No. 8.2. DESCA-Model). (3) Beneficiaries have a right to veto publication under legitimate reasons which are (a) legitimate commercial or academic interests, (b) that the protection of the objecting party's foreground/background is affected (No. 8.3.1.2 DESCA-Model).

12.3.1.3 Joint Technology Initiative

A novel instrument, set up as "joint undertakings" under Art. 187 TFEU, are public-private partnerships (PPP) with shared funding between the European Union and industry. Until October 2010, five joint undertakings have grown out of the Joint

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[11] Developed under the auspices of the UK-Intellectual Property Office and published on its webpage: see www.ipo.gov.uk/lambert, providing model contracts for (one to one) collaboration treaties, and for (multi-party) consortia (Intellectual Property Office n.d.).

[12] The "three model-version" (1–3) became substituted by a "four-model-version" (A–D) which is now found on the IPO-webpage (ibid). The open access strategy (Model 1) became refined and split into two versions (Model A or D). Model A grants partners non-exclusive licences to use results for the purposes of the project and for any other purpose. Model D grants non-exclusive rights to partners as well, however restricts to purposes of the Project only.

[13] European Universities: http://www.eua.be/; Research and Technology Organisations: http://www.earto.org/; 150 major companies: http://www.eirma.org/f3/cmps_index.php?page=home; public research organisations: http://www.protoneurope.org/.

[14] G. Bornemann on 11 March 2010, personal communication.

Technology Initiative. All of them were established in May 2008: the Innovative Medicines Initiative[15]), Advanced Research & Technology for EMbedded Intelligence and Systems (ARTEMIS),[16] Clean Sky,[17] the European Nanoelectronics Advisory Council (ENIAC),[18] and Fuel Cells and Hydrogen (FCH).[19] Each initiative has its own IP policy.

Most recently, the League of European Research Universities (LERU) raised concerns about the IP policy of the Innovative Medicine Initiative (IMI). It voiced objections against three rules which put academic institutions at a disadvantage in relation to industrial partners, compared to participation rules under FP7: (1) Ownership rules would anticipate, although not explicitly, that academic partners assign ownership to research results to industrial partners (here EFPIA). (2) Broad "research use" clauses for industry (including indirect exploitation, "royalty-free-option") deprive academic institutions of their royalties. (3) Access rights are unlimited in time, thus impede exclusive licensing at the end of the project (LERU 2010).

This initiative is interesting because it claims the same rights for academia which, up to now, industry has claimed for itself. Differing from earlier discussions, LERU is concerned about the universities' ownership position, not about academic values which might be affected by patenting (publication, research freedom, communication), nor about the issue of too much patenting or licensing ("royalty staking") (Godt 2008). Universities are concerned that they will be degraded to serve as the workbench of industry without due pay.

12.3.2 National Level

On the national level, the situation is quite similar. After the European Union shifted towards the concept of technology transfer, the member states followed at the beginning of the century – as many countries did worldwide (So et al. 2008).[20] Germany instigated the so-called "Valorization Initiative" ("Verwertungsinitiative") in 2002 when it shifted the patent ownership of academic inventions from individual professors to their universities. Since then, technology-transfer offices have been set up at almost every German public research organisation, including universities. While

[15] http://imi.europa.eu/.

[16] https://www.artemis-ju.eu/.

[17] http://www.cleansky.eu/index.php?arbo_id=83&set_language=en.

[18] European Commission 2010, Press release IP/10/542 of 6. May 2010,

[19] http://ec.europa.eu/research/fch/index_en.cfm.

[20] Interestingly, the same goal of fostering technology transfer was pursued with inverse instruments. In Italy, patent ownership was shifted back to professors in order to liberate their negotiation capacities with industry.

federal funding was cut back in 2011,[21] a consolidation process fostered centralisation either geographically or on the line of technology sectors.

Very similar to the concerns raised by LERU, a 2010-study (focusing on German TTOs) manifested that inventions made inside universities rarely become property of the academic institution (Godt and Marschall 2010: 8 ff.), irrespective of the reform of the Employees' Invention Act (German: Arbeitnehmererfindergesetz) of 2002. Three mechanisms stand out: (1) Ownership rights to inventions might be promised (resp. rights transferred) either to industrial partners or to independent organisations early in the process. In this case the university will not acquire property. (2) The situation is similar in so-called "trust situations". The university will only be the trustee of the patent claim. In terms of the common law, the university holds the "legal title" to claim the patent; the industrial partner is the beneficiary (and will hold its patent ownership as soon as the international patent is issued). Contractual arrangements vary. Sometimes, the transfer is finalised after 18 months when the file has been published by the agency which includes the university's name. The institution can then be researched in data banks and can be credited for the patent in the respective performance indices. Other contracts stipulate that the transfer of property will be executed when the procedure will be shifted from the national to the international phase of the application procedure under the Patent Cooperation Treaty (PCT). In any case, the patent will finally be issued to the industrial partner. (3) The "Fifty-fifty-rule" in Sect. 6.1.3 of the second edition of the Model Contract "Berliner Vertrag" (Goddar and Mohnkopf 2007, 2008; Goddar et al. 2009)[22] stipulates that in the cases of an industrial contribution to an invention above 50 % the whole property title will be assigned to the industrial partner. The rule defines "university results" as being either exclusively or above 50 % assigned to the university (ibid.: 43). It has a double consequence. First, the academic contributions below 49 % will altogether be automatically lost in terms of a proprietary title. Second, an uninformed, consensus-driven "fifty-fifty" formulation in contract negotiations can lead to a loss of (common or joint) property.

12.4 Re-thinking the Role of Universities

These discussions cause unease. Universities are in the process of a profound transformation; however, the direction is fundamentally controversial. There is a broad consent only to one thing: the vision of practical applicability of academic inventions. This expectation was formerly confined to "applied research" (distinguishing

[21] Bundesministerium für Wirtschaft und Technologie (2011) Richtlinie zur Förderung von Hochschulen und Unternehmen bei der rechtlichen Sicherung und wirtschaftlichen Verwertung ihrer innovativen Ideen (SIGNO), 13. Sept. 2011, Bundesanzeiger 147, 3364–3369.

[22] Goddar and Mohnkopf 2007: http://www.ipal.de/fileadmin/user_upload/downloads_wissenswertes/downloads/BerlinerVertrag_Vorwort_TN_Fibel_101007.pdf (accessed 21 September 09); Goddar and Mohnkopf 2008: 142–143; Goddar et al. 2009.

it from basic research). Today, basic research has to equally justify itself with "usefulness" – be it vague or just long term.

What has become unclear is the mission, the goal, the self-understanding of universities. The revenue measure, which seems to dominate today's day-to-day performance in TTOs,[23] is rather an expression of the change than the end in itself. The financial income measure only corresponds to the idea that universities have to stock up the basic public funding which tax-payers provide. In this regard, the leading idea is supplementation, not substitution. Public quests are melded with private yardsticks. The requirement of third-stream money instead reflects the shifts in concepts. The old concept of public finance for public institutions, the safeguarding CUDOS ideal of Robert Merton,[24] has given way to an idea of matching funds – without turning universities into private entities. The vision is "something in between": neither a "splendid isolation, financed by the taxpayer", nor (short term) "profitable knowledge production". The speech about "the entrepreneurial university" describes the direction without precisely defining the status quo. This situation has become intensified with the re-interpretation of the term by concepts of the "Intellectual Entrepreneurship" (Cherwitz and Sullivan 2002; Cherwitz 2005; Gibb and Hannon 2006) which emphasise the intellectual and practical (problem solving) impact of universities on society.

The underlying basis of the overall re-orientation of research institutions (including universities) is more profound. It is rooted in socio-economic changes towards the so-called knowledge and information society. As Münch (2009: 106) noted, technology transfer cannot be foregone since it is not technology transfer which is transforming public research organisations but the overall global developments broadly labelled as information society and globalisation. The emergence of technology transfer seems to be a parallel phenomenon to the lost ability to distinguish basic and applied research. It is a consequence of the acknowledgement that basic research is equal and that it is pursued in industrial research labs to a large extent. Vice versa, industry is interested in collaborations since universities nurture a research spirit, host young minds and provide an environment which industry cannot copy. These descriptions do not deliver the new positioning of public research: Is economic growth better served when universities are turned into entrepreneurial knowledge-producing profit centres, or should public institutions remedy market failures? What about "public responsibility" for invested public money? It should be considered that public research not only plays a central role in cases where private incentives evidently fail (orphan diseases, tropical diseases). Public institutions also play a pivotal role in specific areas, e.g. in diagnostics: Public hospitals and universities account for 76 % of genetic testing laboratory affiliations (Matthijs and Hodgson 2008).

Positions in social science literature are split. Some argue that universities have transformed into entrepreneurial entities (Etzkowitz and Leytesdorff 1997; Acs

[23] Boehmert and Boehmert & Prognos AG 2010.

[24] For an in-depth analysis see Godt 2007: 156; for an early criticism of the implied ideals see Kuhn 1997.

et al. 1992), others argue that different norms in academia and industry subsist and might assume even a greater significance in the face of closer links (David et al. 1998; Mowery and Sampat 2005).

From a regulatory perspective, the new behavioural incentives for attracting third-stream money can be read as instruments which enable new "points of communication" in terms of system theory. As Freitas and Verspagen (2009) pointed out, the motivations of universities and industry to participate in collaborative projects are quite different. The trade-off is **not** characterised by a *do-ut-des* situation which is characterised by the fact that one has something which the other one wants. Freitas and Verspagen speak about the "trade-off in motivational space". They find that the interest in filing applications seldom occurs within each partner for the same reason. Instead, whereas industry is interested in product development, academic researchers are interested in long-term collaborations. This reflects different rationalities in each system. However, what commodification achieves is creating a "common language". It is far from clear whether a commodified technology transfer makes the transfer to industry more likely, or at least not one-dimensional. The process "translates" knowledge into market categories. But IP are only essential for a successful collaboration in a number of exceptional cases (Freitas and Verspagen 2009).

These findings support that the old categorisation does no longer meet the current processes prompted by the "Third Mission". What it does, however, is positioning technology-transfer entities of public research institutions as intermediaries between "idle research" and industry. The proper metaphor is a "hinge-joint", which enables the flow of knowledge and inspiration in both directions.[25] Universities will (and are well advised to) safeguard segments in which behavioural norms are maintained which cushion "idle curiosity" (Merton 1942, 1973: 267). In other parts, they will develop entrepreneurial policies both on faculty level and on the level of each individual scientist. The reconception of public research institutions as intermediaries is by far not trivial. The idea opposes the analysis that universities "turn into" an entrepreneurial entity or that the university has to "defend" itself against this transformation. The concept of an intermediary implies the need to decide by the institution (not only by the policy makers who steer the change). The necessity of a decision in each single situation requires a policy regarding how to execute the room of discretion. What is needed is an enhanced reflection (and at the end criteria) about when and why (which) research institution pursues which way.

[25] The core of the new philosophy is "communication" in "network structures"(e.g. Commission of the European Communities 2007: 6, 13), not generating additional funds.

12.5 Conclusion

From a private lawyer's perspective, the Valorization Initiative has granted universities "more rights" which they can use according to their preferences. Those preferences are not fixed, neither confined to profit maximisation nor to "giving away knowledge assets". From a functional point of view, it seems important to translate the novel function of universities as "intermediaries" into policy concepts and legal terms. At the end, the position of universities will be strengthened because they are different from industry. Their self esteem should be enhanced because they bring about a different type of knowledge. In addition, it has to be acknowledged that most research institutions are financed by public money. Public money comes with public policies which change over time, may be multiple and not always consistent. In addition, public research institutions are entrusted with a public mission which they have to acknowledge. In the long run, universities have to devise policies which ensure that continuous conflicting goals are served on a transparent basis.

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Summary and Recommendations

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The objective of this conference volume was to analyse the changing governance of PhD education and research from an interdisciplinary perspective. Parts I and II presented empirical results from a social science perspective (economics and sociology). The contributions focus on the question how governance changes on the system level or on the organisational level effect the shop-floor-level of research (research training groups, individual researcher, research groups). The contributions in part III studied role of new European governance (ERC, ERA-nets and technology transfer instruments) from a legal and more normative perspective.

The first section of the book deals with the changes in the governance models of PhD-Education. Birgit Pferdmenges, Kerstin Pull and Uschi Backes-Gellner look into the newly introduced Research Training Groups funded by the German Research Foundation from a perspective of team composition research and the organisational resources they question a positive effect of demographic variables. While interdisciplinarity might yield access to additional resources heterogeneity in demographic variables might be linked to social categorisation and harm the social cohesion of the group. Further they assume that there may be differences between the disciplines with respect to the effects of heterogeneity. In fact they can show that heterogeneity in disciplines for the Humanities and Social Sciences has a positive effect on the number of publications by the doctoral students without affecting their completion rates. Albeit internationality has an u-shaped effect on completion rates in RTGs in the Humanities and Social Sciences while their performance in publications stay unaffected. Effects in the Natural and Life Sciences diverge from this pattern. Here they find a hump-shaped relationship between disciplinary heterogeneity and completion rates while publication performances are not affected. After a certain

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degree of disciplinary heterogeneity the gains from it are eaten up by transaction costs and communication problems. Heterogeneity in nationality neither has a linear nor a non-linear relationship to performance. The explanation for these results may be found in the countervailing effects of gaining further resources on the one hand and having to struggle with different perspectives and languages on the other hand. Thus communication problems may exceed the gains from diversity.

Andrea Kottmann compares the effects of the newly introduced instruments in RTGs[1] on time to doctorate to the traditional forms of doctoral training in Germany with respect to four disciplines: Arts, Humanities and Social Sciences, Life Sciences, Natural Sciences and Engineering. Further the effects such as family background, individual biography and educational background were controlled. Indeed Kottmann finds a significantly shorter time to doctorate for doctoral students inside RTGs than those outside RTGs. Albeit the differences are not large, particularly when you take into account that every fifth of the doctoral students outside RTGs had to discontinue his studies for a period of on average 17 months while only 14 % of the students inside RTGs had to discontinue for on average a period of 11 months. The strongest effect of RTGs can be found for engineering with students inside RTGs finishing on average after 45 months compared to outside ones after 60 months. Taking the differences in discontinuations into account there is hardly any difference in the training models.

The differences in disciplines as expected were much more relevant than the type of training model. Doctoral students from natural sciences finish fastest, from arts, humanities and social sciences finish last. Also differences between students inside and outside of RTGs with respect to socio-demographic background, individual biography and educational background turn out to be small. Since students in both groups are high-performers, there is no evidence of a competitive advantage of the RTG model in student input.

Concerning the supervision of PhD training (number of supervisors, interdisciplinarity, collaboration among them) for students of the Life- and Natural Sciences inside and outside RTGs there is not much difference. In both disciplines the old model of one supervisor dominated and interdisciplinary supervision remained rare. Albeit regardless of training mode, cooperation is common among the supervisors in both disciplines. The same is true for engineering, and at a lower level for arts, humanities and social science. Thus differences of time to doctorate were not determined by the form of doctoral training but by disciplines. This is corroborated by the evaluation of supervision by the students. With respect to the evaluation of supervision differences are again determined by disciplines and not by training models. Regardless of training forms the students evaluated the supervision very positive. Natural science students evaluated the quality of supervision best, engineering students worst. Students of arts, humanities and social sciences are in between.

In arts, humanities and social sciences supervisors inside RTGs were evaluated better than those outside, in engineering those outside were evaluated better. In sum, we observe some change in the organisation of supervision with respect to number of supervisors and interdisciplinarity in arts, humanities, social sciences and

[1] These are characterised by stronger organisational framework, a joint research programme, additional study programmes, innovative supervision and competitive access to doctoral education.

engineering, but almost no change in the life and natural sciences. Just in arts, humanities and social sciences the students inside RTGs report a higher degree of integration in collaborative research than those outside. With respect to natural sciences there is almost no difference between the two groups. Across the board, PhD training has not really changed with RTGs. Albeit, RTGs make a difference with respect to allowing more time for working for the PhD, while doctoral students outside RTGs have a lot of additional duties.

As a surprise of a further analysis by a generalized linear model comes the fact that gender and having dependents have lengthened the time to doctorate in RTGs in the art, humanities and social sciences, while there was no problem for students outside RTGs. The negative effect of RTGs on the time to doctorate for females and those with dependents is confirmed by the data of the life science and natural science sample. Only engineering displays a shortening of time to doctorate for females and parents inside RTGs.

Educational background shows the expected effects; particularly the final grade turns out to be a strong factor shortening the time to doctorate for students outside RTGs. The effects in Life Sciences are similar to those in arts, humanities and social sciences, albeit having a father with an academic degree strongly lengthened time to doctorate for doctoral students outside RTGs. Number and interdisciplinarity of supervisors as well as additional activities such as active participation in conferences, publishing or integration in collaborative research have relevant effects on time to doctorate. Additional teaching and research duties lengthened the time to doctorate in both groups while active participation in conferences and additional publications shorten this time for students inside RTGs, albeit lengthened it for those outside RTGs. Particularly a high interest of the supervisor in collaborative research is important for both groups. For those outside RTGs being less integrated into exchange with other experienced scientists lengthens time to doctorate.

Single supervisors and interdisciplinary teams significantly lengthened time to doctorate inside RTGs, but shortened it with respect of students outside RTGs. Additional publishing and participation in research projects and teaching did not lengthen time to doctorate for students inside RTGs but shortened it in the case of additional publication and teaching. For those outside RTGs additional publications and research strongly lengthened the time to doctorate while teaching shortened it. Working with other PhD students shortened time to doctorate in both groups, high interest of the supervisor as well as exchange with other experienced scientists shortened it for those inside RTGs, low interest of the supervisors and little exchange with experienced scientists lengthened it for those outside RTGs.

In natural sciences the gender effects are much smaller; the same is true for engineering. Having a partner during doctoral studies has a strong shortening effect here only inside RTGs; but not so outside as in all other disciplines. Inside RTGs there is again a significant negative effect of having dependents. As a result of the comparison by the GL-Model we find differences between the different training forms that were not visible in the earlier descriptive analysis. Additional publications and active participation in conferences as well as integration into research collaboration and exchange with other PhD students shortened the time to doctorate for those inside RTGs as did having interdisciplinary teams of supervisors. On the contrary, students outside RTGs were both unable to profit from additional publications and active conference participation. Both groups could not profit from further research projects and teaching. Students outside RTGs instead profited from integration into cooperative research projects and exchange with experienced scientists while work with other PhD students significantly prolonged their studies as did an interdisciplinary teams of supervisors, further participation in a research project and a bad final grade.

Engineering students also seem to profit from RTGs in so far as having dependents strongly shortens their time to doctorate inside RTGs while having small effects outside RTGs. Also length and final grade of first study has smaller lengthening effects inside RTGs rather than outside. Single supervisors as well as interdisciplinary teams shorten time to doctorate. Outside RTGs the single supervisor model is more effective, inside the interdisciplinary team model. Additional publications significantly lower time to doctorate outside RTGS, but lengthen it for students outside RTGs. Participation in research projects harms both groups, but those inside RTGs are much less handicapped. They also profit from engagement in teaching while students outside RTGs are heavily affected by teaching duties and active participation in conferences. Finally, a strong interest of the supervisor resp. a lack thereof have relevant effects on time to doctorate, working with other PhD students has positive effects under both condition.

Peter Schneider and Dieter Sadowski present an explorative comparative analysis of the governance configurations of economics departments that support success in the academic placement of PhD students in the US (n = 8), UK (n = 5), and continental Europe (n = 13). As an important context condition, they introduce these countries who differ in the time of and degree in experience of exogenously created competition and hierarchical management of faculties in universities. The authors also expound the problems of the large variety of different configurations of governance structures in the three countries. Further they assume that there are differences in the governance configuration of high (n = 14) and low (n = 12) performers among the economics departments and sampled the departments according to the rankings of Combes and Linnemer (2003). Academic placement success is measured by the relative frequency of placements in top 150 departments and the relative frequency of general placements. From these an indicator with different combinations is built also taking into account the continuity of the performance over the periods studied.

Concerning the factors determining placement success the authors rely on the governance equalizer introduced by de Boer et al. (2007) for the measurement of deviations from two model types of governance, the traditional model of high state regulation and strong academic self-governance and the NPM model of high exogenous competition, strong hierarchies, little state regulation, strong external stakeholders and low academic self-governance. Based on documents, web research and expert interviews they extracted several indicators for the operationalisation of the five governance mechanisms combined to scales of three to six different levels of manifestation of the governance mechanism. This description (*c.f.* Table 4.7) allows analysing this data set by fuzzy-set QCA. This analysis allows finding out which factors are necessary and which are sufficient conditions of either success in placement or failure in placement of PhD-students.

The overall result of these studies is that the existence of a high role of competition in the faculties is a sine qua non for being successful in academic placing. Further interesting results are that combinations of competition with low hierarchy and high academic self-governance or alternatively with low state regulation and high relevance of external stakeholders and high academic self-governance are successful too. Albeit there is little variance in the patterns that drive faculties into failure: no competition, no hierarchy, strong state regulation, no external stakeholders; and no competition, no hierarchy, low state regulation no external and low academic self-governance. Thus it is the pattern of mechanisms that makes for success or failure.

Both models are subjected to further checks of robustness with respect to relevant controlling variables: overall and per capita financial resources, previous publication record, the size of faculties and the number of PhD students. In all tests competition remained as the sole necessary condition for success. Of further interest is that neither a good publication record nor a critical size of faculty or PhD students is a sufficient condition to explain placement success.

Recommendations on Management of Doctoral Studies

From these contributions we can learn that trends in the management of doctoral research programmes have to be scrutinised carefully. Mechanisms that work in one context and situation may not work in another one. Thus science policy makers should be cautious when using on size-fits-all tools. They should allow for discretion of users in their implementation and offer a menu model from which universities, faculties and research teams can choose those options which are cost effective and efficient for their research requirements. The important factor is to mobilise the knowledge of those who do have an understanding of the various disciplines and the conditions of their knowledge production processes.

Newly introduced Research Training Programmes in Germany did not make a strong difference compared to the traditional model. Students inside RTGs did not complete their PhD faster than those in traditional training models. As a much stronger factor influencing conditions of research training we observed the different types of research approach among the disciplines in the samples under study. Thus, it does not come as a surprise that some disciplines adopted elements of the new model and other ones stacked to the old one. This is reflected in the complexity of the interactions between training conditions and disciplines. Other than science policy, supervisors and doctoral students have deeper knowledge on the context conditions of their research project. They are in a better position to manage this complexity and may lose time and resources if they are bound to specific schedules of research training, be it interdisciplinarity, internationality or team supervision and mandatory study programmes. What is a benefit for one discipline – e.g. Social Sciences – may be a problem for natural and life sciences.

Part II of the volume analyses the changes in the governance of universities such as mechanisms aimed at turning universities into corporate actors and the institutionalisation of competitive markets for research funding. The assembled papers enquire into the effects of the strengthening actor hood and competitive pressures on the various levels of universities.

Jürgen Enders, Barbara Kehm and Uwe Schimank (Chap. 5) base their analysis on 16 case studies comparing two disciplines (medieval history and medical biotechnology) and four European countries representing early adopters as well as latecomers (England, The Netherlands, Germany, and Austria) and different rigour in implementing NPM. Arie Rip and Tembile Kulati (Chap. 6) chose their case studies (n = 6) from The Netherlands and South Africa intended to represent different types of multi-level-systems of university governance following Clark (1983).

Enders et al. as well as Jansen et al. define on the NPM governance regime. Enders et al. focus on two important mechanisms:

Strengthening of hierarchical self-governance at top- and intermediate level of the universities and quasi-markets for research funding were implemented. These markets deviate from ideal markets since they lack a large number of potential buyers with a wide array of preferences. Thus, universities and researchers are confronted with almost identical narrowly defined indicator systems to measure, rate and rank their performance in research and teaching. Based on 16 expert interviews they explore effects of evaluation exercises on quality of research, changes in publication strategies, in choice of topics, in the balance of mainstream and risky, long-term research, as well as balance of basic and applied research, and effects on the teaching-research nexus. Their data show evidence for several mechanisms of the NPM concept with partly unintended resp. negative effects on research and teaching. Even the university leaderships acknowledged that it is impossible to compare performance indicators across disciplines. In addition, competitive pressures set incentives for short-termism and maximising the quantity of publications instead of looking for quality (publish or perish) since the next evaluation is looming around the corner. It may come at some surprise for NPM advocates that NPM had no effect on the balance of basic and applied research. In all countries strategic research programmes were established as well as at the European Level. Nevertheless, only those researchers who are engaged in applied research topics and industry collaboration anyway responded to this programmes. Given the heavy role of academic elites in peer review evaluation and the need for applying for third-party money at the research councils academic quality became even more important. The same is true for performance-indicator based funding mechanisms. Researchers on the whole are able to cope with the new expectations and standards by niche building and symbolic compliance to retain a minimum of discretion in setting their research agenda. Monetary incentives are unlikely to change their agenda since research is driven by intrinsic motivation and strive for reputation in one's academic community.

Finally, Enders et al. expect that NPM will push forward the trend towards decoupling the research & teaching nexus. While at the moment a clear trend is only visible in England where since 1992 research money is concentrated on departments ranked at the two highest levels in the RAE while the burden of teaching is uploaded on the lower level universities. The streams of money for research and teaching have been decoupled. Researchers from low ranked departments have little choice to get money from the Research Councils. Money for teaching is distributed simply by quantity of students, without any performance measurement. First trends in this direction can be observed in the other three countries, most clearly in the Netherlands. In Germany the system of quality assurance and evaluation uses different sets of indicators for research and teaching. The availability of differences in performance data at the level of individuals, departments, institutes and universities invites university management and government to further increase the decoupling of research and teaching; *c.f.* the advent of first formalised procedures to apply for a teaching buy-out in a research proposal or reduced teaching loads offered to new professors at German Excellence Universities.

In their paper (Chap. 6) Arie Rip and Tembile Kulati build on a typology of universities differentiating between Classical Elite universities, “Enterprising” universities, and Niche Occupying universities. They suppose that the dynamics of university reform processes are driven by the various stakeholders in the multi-level systems of university governance regimes. University research managers are seen as go-betweens coping between two poles ¬the lateral orientation towards disciplines and domains of application which is dominant at the level of researchers, and vertical orientation to government policies and funding issues dominant at the top level of universities. “Classical Elite” universities are able to continue and expand their core business driven by the shop- floor level. As examples they give MIT, Cambridge, and ETH Zürich. “Enterprising” universities respond strategically to opportunities and are able to adapt their research profiles and competencies to new opportunities. “Niche occupying” universities follow specific mission and thus are dependent on these constituencies. They will change their profiles following the changes in their constituencies. Witwatersrand (South Africa) and Leiden (Netherlands) are chosen to represent Classic Elite universities, Stellenbosch (South Africa) and Twente (Netherlands) represent “Enterprising” universities, and North West (South Africa) and Wageningen (Netherlands) are considered “Niche Occupying” universities.

With respect to the South-African universities only North-West exhibited a clear effort to mobilize resources. All three universities established their research priority areas by marking entities of research excellence and relevance supposed to drive the research mission of the university. Since these centres most often were able to profit from availability of external research resources they enjoyed considerable autonomy vis-à-vis the university management. Horizontal dynamics thus were dominant. Deans and Directors of important centres were encouraged to engage in pro-active management but lacked discretion and resources. Instead they took up the role of spokesperson for their faculty. Thus in the end what happened was dependent on type of faculty and the deans strategy rather than on top-level strategies. The authors even observed the top bypassing the deans and warn that deans will become superfluous if this becomes a regular practice. The authors explain the finding of little differences between the three universities and their extent of strategic research management in South Africa by the role of a still strong patronage culture in a young democracy. Universities still strive for profit from a clientel-oriented funding system as well as for international funding sources to gain more autonomy. The perspective of relevant funding resources easily can overwrite top-level research priorities and by-pass the dean.

The situation is quite different in the Netherlands where all universities are under substantial pressure from competition and pushed to become strategic actors. New Public Management concepts such as delegation and performance indicators are drawn upon. A mediation type of culture is typical also for the relationship between the government and the universities, as well as in the universities. Since the universities under study are well established players at international level, they can deal with evaluation exercises and other research management approaches quite relaxed. Also existing strengths (Twente) are exploited and new ones built up (Wageningen, Leiden). Deans and directors are supposed to manage the tension in the multi-level systems and do so in different ways. Leiden (a classic elite university) allows for more variety and follows a smoother path while in Twente (Entrepreneurial university) and Wageningen (Niche-occupying university) power plays between faculties and the top level can be observed. Twente separated discretion in research management from the middle level of the faculties and established a number of research centres whose scientific directors were positioned at the same level as the deans in the university hierarchy. These centres operate in markets of strategic research which gives them a high level of resources and autonomy, thus a strong position vis-à-vis the university leadership. Overall, the authors, in contrast to Enders et al. (Chap. 5), foresee a trend of convergence between classical elite universities taking up elements of the "Entrepreneurial" universities and vice versa. In addition they acknowledge the centrifugal dynamics based on the tension between education and research mission, but suggest that the vision of the university as a homogenous organisation has to be replaced by a more heterogeneous complex organisation. This – in their perspective would also allow for more differentiated research management strategies, instead of the nowadays typical "one-size-fits-all" approaches.

In Chap. 7 Dorothea Jansen, Regina von Görtz and Richard Heidler explore the effects of New Public Management and the strengthening of the competencies of top and middle management on the shop floor level of research groups in three different disciplinary fields: Astrophysics representing a classic paradigmatic-oriented basic science discipline, Nano science as a new science with diverging research lines, often taken as "Mode-2" discipline by science policy makers, and economics as a social science. Based on expert interviews (2004) and posted questionnaires and telephone interviews (2006/2007 and 2009) of principal investigators they can show a trend towards a strengthening of the role of organisation's priorities for the choice of research lines and the choice of network partners. While in 2004 these effects were almost non-existent by 2006/2007 and 2009 their role and effect clearly had increased and became an important point to observe in shop floor research planning. Thus after a period of latency, governance changes resulted in the strengthening of Actorhood of universities as well as an increase of their influence on research production processes. Albeit, still comparing universities and mostly mono-disciplinary institutes from the non-university research sector, exhibits that in these sector, the effect on research lines and networks is larger. This may be due to the low degree of heterogeneity in these institutes allowing for consensus-building in setting research priorities. A similar picture can be shown with respect to the effects of programmatic priorities of research funders and network-related demands such as internationalisation or collaboration with industry. With respect to disciplinary network choices an important result is their discipline-related heterogeneity: While Astrophysics prefers to choose from a pool of known partners, Nano scientists most often choose their partners strategically with respect to the research subject. All disciplines combine both network strategies.

Further the authors deal with the problems resulting from steering efforts of research organisations, external funders and other intermediating agencies such as evaluation agencies as well as of science policy makers. Steering by incentives in a system that lacks clear and easily measureable outputs is very demanding. Knowledge production e.g. rests on several inputs and throughputs, in particular on the education of graduates and post-docs and on contributions to the infrastructure of the publication and communication system of science (*c.f.* Fig. 7.1). If intermediate products as these are no longer honoured by incentives, scientists will abstain from these tasks and concentrate on the monetary more attractive ones. In addition the qualitative interviews show that scientists are aware of their strengths. They specialise in those tasks which allow them a high performance. In addition there is a high demand in complementary outputs. Thus given the narrowly confined science performance indicator-systems such as third party money only, there is a danger of shortage of intermediary products in science communication infrastructure and good graduate students. A process of de-differentiation may finally lead to an engagement of most scientists in the most honoured product – third party money, at the loss of research quality and the deterioration of science communication infrastructure. This discloses the problem of the popular use of third-party money as indicator of scientific performance (which should have a monotonous effect on final outputs such as publication and no negative effect on these and other throughputs such as the science communication infrastructure system).

Instead TPF is again a throughput and by now a necessary condition for being able to do research in most research organisations and particularly in universities. As Fig. 7.3 shows the effect of proportion of time that research groups invest in third-party funded research has an inverted U-shape. This signals decreasing returns at different turning points for each discipline. The results were corroborated with even lower turning points for Astrophysics and Nano science by a further study with a larger sample, except for Economics (Schmoch et al. 2010). Nevertheless although amount of third party money does not say much on scientific performance (efficiency of knowledge creation) it is often the only indicator used for research performance in the formal indicator-based performance-budgeting system in Germany (LoM), which obviously has not been implemented at the shop floor level thoroughly. In 2006/2007 only half of the research groups report that the allocation of their research resources depend on LoM, despite of the wide spread of LoM at the university level. Just a quarter of the research groups see a noticeable change in resources resulting in increasing efforts to acquire TPFs. Thus, LoM at the level of federal states and of the universities supports the strengthening of actorhood of universities. Another problematic effect is an increase in mainstreaming of research by TPF-related peer review processes (*c.f.* Wissenschaftsrat 2011). Institutional funding is central for doing unconventional research. LoM affected research groups show more risk-averseness to engage in high-risk research projects with unclear methods and uncertainty of success. Instead they apply for TPF with standard projects.

With respect to the steering efforts targeted at network size and type the authors show evidence that an observation of priority of funders as well as increasing network size may have unintended effects. Funder's priorities as well as size of the research group clearly have positive influence on the number of publications, significant only for network size. Albeit in all three disciplines the quadratic term of network size has a negative sign, significant only for economics. This reflects the fact that building and maintaining of research networks are costly. The larger the network the higher the transaction costs. Only interviews allowed finding out about this while the usual indicator of co-publication implies that successful publishing by the collaboration network. The same is true for strong incentives to collaborate with industry partners with respect to Nano science. Nano science has the highest percentage of industry partners in their networks. Again the coefficient of the quadratic term is negative for the percentage of industry in the networks. Thus some industry partners increase performance but there is a rather low threshold were decreasing returns set on. Another subject dealt with is the relationship between structure of the network and scientific performance. The authors compare astrophysics networks and Nano science networks. Astrophysics is characterized as an old established science following convergent paradigmatic research lines. Astrophysics needs the access to large instruments managed by big science labs. Large equipment is important and depends on stable ties to highly reputed colleagues. Nano science is a new science with highly divergent research lines. Researchers need a large variety of materials and mostly multi-purpose equipment. The authors can corroborate their thesis and find that for Nano science heterogeneous open network are advantageous while astrophysics profits from stable, closed networks. At their surprise they find no significant difference in the constraints of Nano science and astrophysics networks. At the same time the researchers describe the demands they expect from research collaboration partners correctly and follow suitable network strategies.

In Chap. 8 Andrea Bonaccorsi starts from a question of Soskice (in: Hall and Soskice 2001), asking why in Germany a major force in scientific research, technology, and high technology industry, has systematically failed to gain a leadership position in two important industries – Information Technology and Biotechnology. He shows that the broad institutional features of the German economic system are conflicting with fields of technology which are characterised by extremely high risk and volatility, low chances for finding complementary of knowledge, and low loyalty in buyer-supplier relations. He also shows how, with intense policy commitment and investment, Germany succeeded in two niches in these industries, which are characterised by somewhat less extreme conditions, namely Business software and Diagnostics. In a chapter in the same book, however, it is argued that there is no evidence for a systematic relation between institutional features of countries and their innovative performance. By using patents as an indicator of technological performance, he rejects the main claim of the "diversity of capitalism" (DoC) thesis.

Bonaccorsi shows in his paper that, somewhat paradoxically, both claims are right, but with a qualification. It is not appropriate to study the relations between institutional features of countries and technological performance in a direct way. This relation is not direct, but mediated. An important mediating factor is given by the features of the scientific system. What is missing in their analysis is a specific treatment of the scientific system as an actor in the innovation process in high technology. While the scientific system reflects, by definition, some of the more general features of the institutions of a country, still it takes some specific attribute which must be studied per se. In addition, scientific systems are in constant competition, so that some pressure towards institutional isomorphism may be more powerful than in other sub-systems. Therefore, Bonaccorsi suggests to apply the DoC framework to the scientific system, and to explore to what extent its features may be held responsible for variations in scientific performance across countries. He offers evidence from a case study, namely, the patterns of mobility and performance of top 1,000 scientists in the field of Computer Science, as shown from an extensive analysis of their CVs. The analysis shows that Computer Science combines the elements of new science and search regimes and the scientific institutions supporting such a regime of scientific knowledge production have exhibited properties of flexibility and mobility, in all possible dimensions (disciplines, career, geography).

He builds up a framework for comparative institutional analysis of scientific systems, along dimensions that are related to the VoC (Variety of Capitalism) framework, but are more specific. He compares several dimensions of the science systems: creation of skills, recruitment and career of researchers, public funding of research, institutional complementarities, and academic governance. These are compared with respect to the continental and the competitive type of science system. Bonaccorsi finds that a competitive model of doctoral training (*c.f.* Chap. 3 too) has a positive effect on chances for new sciences, as well as a competitive strategy in recruiting of scientists by highly autonomous faculties compared to formal administration process. In addition he finds allocation of resources by the national Science Ministries furthers the chances of new sciences as well as a turn from an academic governance form to a hierarchical management model. The overall VoC is then reformulated this way: institutional features of scientific systems of states are responsible for differences in cross-country scientific performance; to the extent that scientific performance is a non-substitutable input in technological development and industry production. They also are partially responsible for cross-country differences in technological and industrial performance. Concerning necessary institutional complementarities with respect to industry collaboration he lists several problems such as a lack of incentives for academic researchers to collaborate with non-scientific institutions, a non-professional approach of universities to commercialisation of research, the lack of a history of a track of collaboration, focus on collaboration mainly with large incumbent firms, instead of pursuing both incumbent and start-ups-firms, low chances for mobility in the career and for change of institutions. Thus, Bonaccorsi reinterprets Soskice' labour market model and discusses the complementarities for new science (*c.f.* Table 8.7 and Sect. 7.5.2; Sect. 9.2; Sect. 10.4.1 concerning difficulties of new sciences with funding decision rules of peer reviews).

Recommendations on Governance and Steering Mechanisms

As Enders et al. conclude, NPM is a mixed blessing. Instruments such as performance related salary components and budgets are important in England (RAE) but do not play a strong role in Germany and Austria; in the Netherlands they do not have direct effects but are used to inform the university management and research funding agencies. Many instruments are clearly dysfunctional and load bureaucratic burdens on academics at the cost of their research time. Researchers claim that quality management has not influenced their research in any way apart from being a waste of precious research time. The need for research management was accepted by all researchers; however, the instruments and measures taken were seen as not effective. Instead time and resources should be used for restructuring and profile building. Other instruments have ambivalent effects such as evaluation exercises and peer review – these will push the productivity of researchers, i.e. the quantity of publications but lower quality and shrink the variety pool. NPM will in addition lead to a trend of decoupling of research and teaching and a further differentiation triggered by the concentration of research money on highly evaluated universities at the cost of the lower levels university and of teaching quality and junior researchers, an important intermediating product of academic organisations, needed for the Science System. After all, it is not possible to give clear policy recommendations with respect to NPM. Given that the evidences presented here are confirmed, science policy makers should neither return towards the status quo ante nor to perpetuate radical NPM reforms. Instead they suggest a careful point-by-point comparison of how the old governance regime worked and the effects of cautious steps into the direction of the NPM regime. They also advise science policy makers to be aware that this implies that they should be prepared to modify the system.

Similar to Chap. 5, Rip and Tembile in their Chapter agree on the likely loss of the research & teaching nexus, but evaluate it quite different. In addition, both state the problem of simple "one-size-fits-all strategies" in research management. Enders et al. in addition present evidence that all academics they spoke to were aware of the necessity of research management. But the instruments they had at hand have been seen as ineffective and nonsense without any effects except loss of research time. Restructuring the university by establishing research centres or clusters combining different disciplinary perspectives were welcomed as a meaningful, sapient strategy. Academics still are used to work in different roles and belong to different entities, faculties, associated research entities, and their scientific communities. Thus there may be a chance to manage a heterogeneous university without leaving the teaching mission behind the research mission; and there may be a chance that the value and need for basic research is acknowledged between the interdisciplinary research centres and their home university.

Jansen et al. in Chap. 7 also pointed to several unintended effects of improper steering instruments and indicators from the new governance of research, such as mainstreaming effects from peer review process, performance-indicator-based funding and, priorities of funders and organisations. Thereby the chances for ground-breaking innovations in new sciences will be lowered. Important points here are to be aware of the multi-level structure and interdependencies of the science system, the multi-dimensionality of research performance as well as the disciplinary differences in knowledge production processes. State ministries and universities often have an interest in the university to increase the university budget by acquiring further external money at the cost of a reduction of institutional funding. In addition, third party money is an indicator that can easily be collected and managed with the help of available budget data. Albeit, institutional funding is the most important source that allows for funding of open-ended research.

In Chap. 8 Bonaccorsi discusses the role of complementarities of institutions with respect to National Science Systems and builds a framework for such a model, transferring dimensions from VoC to Science. He differentiates between to model types, a competitive model and a continental consensus model. In addition he points out the features of new sciences and looks into their demand of complementary in the dimensions: Cognitive, technical and institutional. Cognitive complementarity refers to chances for combination, interdisciplinarity, since new sciences need explanations based on the most elementary levels of reality. In addition they need experimental infrastructure of a smaller type than Big Science, and they often need to go beyond laboratory studies, implying to collaborate with non-scientific organisations such as Hospitals and an epistemic need to collaborate with industry. He, again presents evidence on the problem for getting funding for unconventional ground-breaking research ideas from the funding agencies, the mainstreaming tendencies resulting from the peer review system, and the effect of shrinking of variety pools, which are of utmost importance in new sciences. Thus, science policy makers should pay attention to the institutions of the national science systems and their governance effects as well as to horizontal and vertical interdependencies within the science systems.

Part III of the book is devoted to the strengthening of the influence of EU Research Policy on the National Science Systems. In Chap. 9 Thomas Gross and Renzi Karaalp analyse the new funding system of the European Research Council (ERC) claiming to become a world class Frontier Research Organisation in the long term. The paper addresses the missions of this new research funding organisation founded in 2007, the organisational structure and the rules of procedures for the selection of the grants. Also the recommendations of the "Panel of independent experts for the review of the structures and mechanisms of the ERC" about the institutional concept of the ERC are taken into account. As the funds of the ERC are restricted the number of grants is quite small and therefore the success rate is low. The structure of the ERC is based on a strict separation of scientific and administrative tasks. The evaluation of proposals is made in the peer review procedure, a two stage evaluation process performed by specialised evaluation panels and referees. The Executive Agency of the ERC reporting to the Commission concludes grant agreements and handles all financial transactions in a quite cumbersome way for the research institutions funded. The paper points out, that "trust" by the scientific community is one of the main requirements of the Governance of the ERC. For this purpose a "cascade" procedure of selections of the scientists involved has been created. Also important is trust in the fairness of procedure. This is reflected in strict rules on conflict of interests, a high degree of transparency and proper redress procedures. While legal procedures were evaluated as adequate in the mid-term report the handling of the rules by the Executive Agency – were strongly criticised. As the Mid Term Report describes, the separation of Scientific Council (scientific decisions) and Executive Agency (management) is artificial and not efficient, and the appointment of administrative positions of the Executive Agency and its Director by renowned scientists would be helpful. The problem is not that fairness of the process is debated, but that the handling of financial and personnel issues applicable to the Agency do not fit to peculiar requisites of basic and particularly new science funding.

Further, they come to the conclusion, that the statute of the executive agencies is not flexible enough to guarantee best practices and scientific standards in evaluation and administration. Based on the example of the most successful national funding organisations full autonomy of the ERC should be reached by creating an independent body on the basis of Article 171 ECT. The legal quality of the ERC is taken into doubt, since it does not correspond to European organizational law. As the authors complain, the role of the Scientific Council described by support to the Commission in funding pioneer research does not hit the point. The Commission appoints the members of the Scientific Council and has to approve important decisions. The independence of the Scientific Council has to be guaranteed by the Programme Ideas. Collaboration between Science Council and Executive Agency is hampered by appointment of mostly members of the commission and just one member of the Scientific Council, and the Secretary General as observers. Another board had to be created containing ERC president and two vice presidents, ERC Secretary General and the Director of ERC Executive Agency.

Philippe Laredo presents in Chap. 10 recommendations on how to design an organisation aiming at the support of frontier research. He discusses and comments on a number of analyses of the rationales and processes that explain the creation of the ERC. Many analysts see its roots deep in the construction of the European Community, and more specifically at the creation of the European Commission and its perspective about European research with its four dimensions. Nedeva sees the ERC as an answer to the tension "between the inherently global nature of the research fields and the localised, mostly national, research spaces". She suggests that such a social process can only materialise if three conditions are fulfilled: the existence of a change champion, some level of institutionalisation and organisation building is need (referring to the Commission change of views on the issues within 1 year, at Dublin conference 2004). In addition Laredo asks for a progressive emergence of conditions (commensurability of funding rules, organisational set-up for research) that render the enlargement audible by national spaces, particularly the dominance of the agency model of funding with in particular the creation of the French ANR, and the central role given to universities as research performers in most countries at the turn of the twenty-first century. Laredo adds another aspect that is not explained yet, the institutional focus given to the ERC: it is not simply academic or fundamental or basic research, the classical OECD categories; it is focused on ‘frontier research’ as is well outlined by the few extracts taken from the 2008 work programme. At the same time these extracts show that the concept is not that clearly established: is the research ‘frontier’ per se, or is it ‘frontier’ because it is located at the ‘frontiers of knowledge’ (which could correspond to the fields that the ISI web of knowledge defines as frontier), or is it qualified as such because it is ‘unconventional’ (others say heterodox) and/or of a ‘ground-breaking nature’? He lists first as a fundamental principle, which the ERC has to stimulate investor-driven frontier research on the basis of excellence. and ERC Advanced Grants should provide an opportunity to established scientists and scholars. Funded projects should be asked to demonstrate the ground-breaking nature of the research.

Critically he amends that official reports (such as the 2003 Mayor report) were far less precise in their recommendations speaking of ‘research excellence’, of ‘investigator driven research of the highest quality’, or of ‘basic’, ‘interdisciplinary’ and ‘risk-taking’ projects. In his paper he takes this goal for granted and discusses the coherence of this objective with the organisational arrangements arrived at. In a first part, he compares several definitions of the fuzzy concept of frontier research, by looking at the work by EC expert groups and enlarging it to the US and the recent (2009) initiative by the DoE and its ‘energy frontier research centres’. This allows the author to define five entry points that existing literature offers to further delineate the contents of this concept. Frontier research is typically high risk research and stands at the forefront of creating new knowledge and understanding in theoretical and empirical understanding. Other than frontier research, basic or applied research can be done by one or another, but not by both. Further frontier research crosses disciplinary boundaries.

Laredo compares this concept to the concept of transformative research of the National Science Board for the NSF in the US and of NIH with Europe and the DoE approach. He further discriminates between an evolutionary and revolutionary progress which may throw over existing paradigms. While the further type of research is prevailing in the research landscape the latter is less frequent and results in the creation of a new science field. The US Department of Energy gave another answer starting with the assumption that available knowledge and technologies would not help, but radically new technologies would be needed. An expert team (Basic Energy Sciences Advisory Committee) was appointed to identify the “scientific challenges” which were discussed from an interdisciplinary perspective and described as a new area of science in which materials functionalities would be designed by chemical transformations at will. Thereby they delivered not only the first procedural step but also hints at cognitive gaps and relevant contents. Finally the DoE newly established “Energy Frontier Research Centres”, where skills and talents of investigators with different competencies and skills were brought together as an organisational answer to the challenges. Laredo then discusses the options for European Research (*c.f.* Table 8.7 and Sect. 7.5.2; Sect. 10.4.1 concerning difficulties of new sciences with funding decision rules of peer reviews). Laredo here presents evidence on important problems for frontier researchers. Most of peer reviewers are incumbents that take for granted the old paradigms and skills, deny revolutionary breakthroughs and don't accept new research methods. DoE sees this as the main factor that NSF and NIH review processes do not fit to ground-breaking research applications (despite the addition of this new category for applications) and result in low success rates of unconventional applications. In addition he presents evidence on committee rules and "respecting disciplinary sovereignty", leading to favouring of reviewers for their own research fields and methods, as well as to preferences for robust projects compared to risky ones. He therefore worries about the chances that the ERC Funding System would be able to help frontier researchers and suspects that the most of money will go to normal science applications while frontier unorthodox research will only be appraised in case there is a left-over of satisfying the mainstream.

His question is, what does the ERC need to be able to accommodate different knowledge dynamics, i.e. old sciences with low growth rates and new sciences with high rates? How can the performance difference between EU and US Science Systems be closed? Laredo postulates that the so called European Paradox is not a result of low capacity of European countries in technology transfer to industry, but in a lower level of performance in the new sciences compared with the US. He sees the US-advantage as a result of a different funding policy, concentrating funding on a few of agencies (NSF, NIH, DOE, DOD, DHS) that coordinate and share complex tasks such as the National Nanotechnology Initiative (NNI), while in Europe at least 10 agencies with relevant programmes und 4–5 National Programs and presents some evidence on this by a case study on Chemistry and Catalysis. Summarising, Laredo states that the central issue is not to add another agency, but to discuss a new model of European Research Funding and an greater amalgamation of funding bodies in Europe, thus institution building (*c.f.* Table 8.7 and Sect. 7.5.2; Sect. 10.4.1 concerning difficulties of new sciences with funding decision rules of peer reviews). He suggests building up an agency of agencies. This could build on the experiences made with the collaboration of national states with the ERA-Net Program and the ESFRI-Programme. He suggests that the ERC should not use all its funds in its own "all-over-the board calls" but keep a significant share to experiment, together with national agencies.

Recommendations on the Mission and Structure of the ERC

Gross and Karaalp, as well as Laredo criticise the structure and procedures. While the cascade model of the peer review process is not seen as a problem, both papers complain on the handling of the rules by the Executive Agency and its inflexibility is seen as a problem. The legal quality of the ERC is taken into doubt, since it does not correspond to European organizational law implying that the independence of the ERC gets under doubts. Instead, collaboration between Science Council and Executive Agency is hampered by appointment of mostly members of the commission and just one member of the Scientific Council, and the Secretary General as observers. They suggest to instead the ERC president and two vice presidents, ERC

Secretary General and the Director of ERC Executive Agency should be members of the board, which would to smoothen the administrative procedures of research funding management.

Laredo shows evidence on the performance of other countries/institutions and presents the model of the DoE (*c.f.* pp. 201–204) as a best practice. As Bonaccorsi, he complains that the ERC model again will favour mostly mainstream research and thus, just the rest of the money will not be able to support research projects of new sciences. In addition the approach of forcing research applications into a given research agenda will hamper creativity and again reduce the variety pool. As a model to cure these problems he suggests an agency of (national) agencies such as ERA Net-plus in order to better coordinate funding and allow to guard more research money for risky ground-breaking research.

In Chap. 11 Arne Pilniok analyses from a public law perspective the changes of European Governance of Research, particularly how the Commission used the concept of the European Research Area and its implementation into Article 179 par 1 TFEU and the normative institutionalisation of this goal in 181 TFEU with a broad definition of coordination instruments. He expounds potential problems since competences in RTD policy stay with the members states, while a multi-level-governance system is created that depends on coordination which is not clearly defined. Mostly, in the member states independent agencies of research funding administer research programmes and research funding. In addition, some members are federal states in which the competences for RTD policy are distributed to lower levels. Therefore, the scope of coordination actions is limited to non-binding instruments, which depends on voluntary cooperation of the Member States. Therefore, the Commission based its strategy on other instruments, such as the Open Method of Coordination, soft law based on the coordination competence and a high number of Committees working at the EU level.

Pilniok – other than many studies – does not see OMC as a new governance instrument – but identifies a limited mode of governance instruments -competition, negotiation and networks are used by the EU. OMC in RTD was started with benchmarking projects for comparative assessments by indicators assembled by expert working groups, national RTD-ministries, and statistical agencies and researchers and research organisations. Albeit – due to problems with the measurement instruments and the continuous resistance of the Member States the benchmarking project failed. Instead the DG Research established a department for monitoring national research policies outside the OMC context. OMC, since 2003 – depends on the creation of thematically-oriented networks, organised within the CREST, a joint Committee of the council (Member State's RTD ministries) and the DG RTD with the objective of exchanging best practice. CREST chooses topics of common interest for the Member States on which working groups are installed which formulate recommendations from CREST. Further CREST organises peer reviews of Member States RTD policy on a voluntary basis resulting in recommendation each year. Further CREST is connected to the Framework Programme via the CREST-Net, which has been established by the Commission to overcome its marginal role in the OMC process. Governance by Committees and their Recommendations is the main change in the governance of RTD policies in the EU identified by Pilniok. Albeit, he amends that the model recommended clearly emphasises the functional dependence of research and economy. Further, the success of multi-level-systems cannot be measured separately. The complex system also poses questions on accountability and legitimacy and the opacity of OMC, so Pilniok- has often been criticised. But he also admits, that the situation has changed meanwhile. Now, all documents of CREST are online available. Thus, Pilniok comes to the conclusion that policy changes are not based on competition, but on a deliberative type of OMC meaning learning by persuasion and learning from successful examples, based on knowledge and indicators on performance delivered by the OMC to the national parliaments, allowing them to hold national government accountable.

Stronger effects on the governance of national research policy by the EU are identified for ERA-Nets, and Dedicated Implementation Structures. The ERA –Net-Scheme - included into the 6th Framework Programme and amended in FP 7 by a common-pot budget of the DG Research, was implemented as an incentive for competition among the national funding agencies. While in FP 6 topics for ERA-Nets could be freely chosen, in FP 7 they were defined by calls of the DG Research. The coordination of national research-funding programmes and part of funding passed to the Commission. Based on Article 185 TFEU, based on contracts for selective building of consortia, these measures of the EU have changed the relationships between the European and the national level of research funding, and have introduced new forms of governance in the EU. Thus, normatively strong governance structures with respect to the contracts of the consortia of national funding organisations (meso), their relationship to the EU (macro) and to the research applicants/ investigators (micro) in a multi-level system were implemented.

Another type of measure based on Article 185 TFEU allows the Commission to implement decisions. Here the EU has a strong position in the legislative process. She defines the topics of the Framework Programme and is given the monopoly on initiative. On the other hand, competitive elements are scarce in the second measure discussed. The Commission only exercises its right of initiative, which is based on former experience with Member States cooperating in specific research fields. The legislative procedure here is more conflict-loaded and takes much more time. Dedicated Implementation Structures are legally based on corporate law –thus a governance mix of public and private evolves. Typically the European "Economic Interest Grouping" with unlimited liability for all actors is a legal structure to facilitate cooperation between public and corporate actors. Pilniok resumes that this formalised course of integration is limited to a small number of fields. since formal commitments of member states to match the amount of funding from the EU are implied.

Contracts are employed for steering research inside universities, for the building of consortia across national borders and for cooperation between governments and industry. Arrangements about property, especially intellectual property, are key in forming European research collaborations and fostering technology transfer from academia to industry.

Thus the governance of research funding and policy changed clearly. Within the ERC the networks that connect European and national research funding created a new type of institution with complex horizontal and vertical governance structures. National research funders are involved in these overlapping networks and lose their authority on research funding rules. Pilniok thus sees problems for research themes of mainly national interests to come. In addition he again criticises problems with respect to accountability and legitimacy. Judicial supervision of the funding decisions taken at a transnational level is mostly absent. Decisions on ERA Net Consortia of national funders and their governance structures either lack judicial supervision or are at least depending on the national judiciary system. In addition the accountability of consortia and networks towards the parliaments seems unclear. Beyond the reporting towards the Commission and the EU parliament, there is no regulation of reporting requirements to the national parliaments. As Pilniok complains, this problem is most relevant for the ERA-Nets distributing national research funds.

In Chap. 12, Christine Godt focusses on the new role of Technology Transfer as a Third Mission of Universities and the related trend towards increasing their autonomy and actor competencies. In particular she sheds light on the change of the meaning of Technology Transfer since the implementation of Technology Transfer as a mission of Higher Education Institutions as an additional mission into the Law on German Higher Education in 1998. Since then, a commodification of academic innovations via patenting and the idea of improving competitiveness of a knowledge-based economy by property-protected effects of innovation became relevant. The assignment of property rights of inventions to individuals in universities was replaced by assignment to the University as an actor. Thus new arrangements between academia and industry had to be made. This is different from the typical, but often not planned, spill over effects of academic knowledge to industry. Technology Transfer is meant by now as intentional, specific and proprietary. This poses problems for the Universities who struggle with their third mission and the deviation from academic values. Godt starts with a back sight on the history of technology transfer in the EU. Ever since the implementation of R&D Policy into EU Treaty of 1986, the EU focused on fostering industrial collaboration and sharing knowledge. The most important instrument was the Framework Programme. The Bayh-Dole Act, in the 1990 inspired science politics to change towards supporting academic research and enabling property-secured technology transfer. The turnaround came between FP4 and FP5, now allowing participants to grant exclusive licences for knowledge from their funded research. The concept of mode-2 and Triple Helix supported these ideas. Albeit, she points to several problems, such as the threat that universities might lose their independence and become workbenches for industry. The specificities of public research, that is able to take up research in not profitable areas might be lost. Even the EU Commission and the US National Research Council were aware of this conflict between profit and the public value. The latter concluded that technology transfer offices no longer should have to earn their money from patent/licence income and that better instruments to secure public accountability are needed.

Godt also points out that this type of collaboration between academia and industry leads to mixed evidences in the US (top 100 innovations of the year from collaboration include business and federal labs and federally funded Universities) and Europe.

From a Macroeconomic point of view academic institutions contribute largely to technology transfer. Also European firms increasingly rely on external (including academic) knowledge sources which are integrated into a distributed inter-organisational network. In particular, research partnerships between academic actors and industry have gained in importance compared to more arms-length and commercially-driven types of links such as the exploitation of scientific publications, university patents and recruitment of graduates. Albeit, universities might run into risks to be deprived of future options for in-house-research. While publication delay is no longer an issue, there is scepticism on the chances to get access and the process of research as a whole. To engage in unconventional research is getting more difficult and researchers increasingly prefer mainstream research areas. Proprietary arrangements lead to requirements to ask colleagues for permission to do research, and keep newcomers out from patent thickets thus hinder their chances to have competent colleagues for reviewing their applications. She focuses on two instruments, the Framework-Programme as the most important instrument by which the EU Research Policy could determinate specific topics and the requirement of collaboration with industry. This instrument of EU RTD policy shaped the network building by setting up default participation rules that state that property rights are not jointly owned but belong to the participant who invented it (*c.f.* Chap. 11, Sects. 11.3.2 and 11.4) Exploitation of patents is done by exclusive licences and transfer. In case joint owner's property rules were not agreed on, each joint owner is allowed to sub-licence after prior notice, granting fair and reasonable compensation. In addition access rights to projects results and knowledge brought into the project, royalty free. This may be limited to research purposes. Albeit, she points to a potential problem since the right to use the project results is limited to 1 year after the end of the project.

Further she traces the reduction of the variety of contract models used in Framework Programmes with the new DESCA models. Taken from the Lambert Kit DESCA Consortium model 1 grants each of the others a non –exclusive royalty-free license to use its results for the project, and for any other purpose and it states that any member may exploit any of the results while Consortium Model 2 and 3 gave more rights to industry. By now the Model 1 was split into Model A which grants partners non-exclusive licenses to use results for the purpose of the project and any other purpose. Model D also grants non-exclusive licenses, but for the project only. DESCA Model 1 became the reference models since FP 7 and is used by 80 % of Consortia. Godt supports this model since it allows joint ownerships for all partners. They have the right to licence (unless other agreements were taken) after prior notice and subject to fair and reasonable compensation. Another option is to renounce without further notion. As another reasonable addition she mentions that partners are allowed to transfer foreground with or without further notion and the option for beneficiaries to forbid publication in case of legitimate commercial or academic interests, or the protection of foreground/back ground is affected.

Finally, Godt deals with the property right regulation within Joint Technology Initiatives. After a short introduction she criticises the LERU Manifest which raised concerns about the IP-policy of the Innovative Medicine Initiative, and complains on disadvantages of academic institutions compared to FP 7. Ownership rules would include that academic institutions assign ownership to industry, broad research use clauses for industry, and deprive academic institutions of their royalties by granting unlimited access rights to industry, thus impeding exclusive licensing at the end of the project. She takes these collections of demands as a hint towards overtaking of industrial culture at the loss of academic culture.

From a private lawyer's perspective, technology transfer initiatives have granted universities "more rights" which they can use according to their preferences. Those preferences are not fixed, neither confined to profit maximisation nor to "giving away knowledge assets". From a functional point of view, it seems important to translate the novel function of universities as "intermediaries" into policy concepts and legal terms. (1) Universities are important because they are different from industry. This is because they bring about a different type of knowledge. (2) Most of them are financed by public money. Therefore, the public mission has to be taken on board. In the long run, universities have to devise policies which ensure that continuous conflicting goals are served on a transparent basis.

Recommendations on EU Research Funding Instruments

Pilniok as well as Godt shade light on some relevant effects of newly introduced EU funding mechanisms. Since FP 6, conditions of funding for ERA-Nets and FP7 framework have changed for researchers and funders (also compare for Godt Chap. 12, Sect. 12.2 with respect to the role of Framework Programmes since FP 7). At the micro-level of research collaborations, FP 7 abandoned freedom of research by requiring adapting their research applications to given research agendas developed by CREST-Net, a research network of industry. In addition CREST and a Council of Member States Ministries organise peer review of Member States RTD Policy. ERA-Net-Scheme now includes a common pot for the DG Research in FP 7. Again research topics were developed by the EU. Thus coordination of research-funding programmes and part of funding passed to the EU. Within ERC the networks that connect European and national research funding created a complex new type of organisation. National research funders are involved in these networks lose their authority on research funding rules, which may lead to problems to fund research topics of mainly national interest. Pilniok in addition affirms the analysis by Gross and Karaalp on the legal problems concerning supervision of the ERC and states the same problems for ERA Net Consortia. Transparency and accountability get unclear within these complex organisations of overlapping networks and institutions. For ERA-Nets there is no regulation of reporting requirements beyond reporting to the Commission and the EU parliament.

Godt warns on the effects of changes of property right regulations since FP 7 with respect to the new default property rules of research consortia. These rules do not give all partners joint property rules but only exclusive licences. In order to choose a joint intellectual property right this must be agreed upon formally. She fears that risk-averse researchers may abandon risky projects and opt for mainstream applications instead and universities become work-benches for industry. In addition universities, deprived from their intellectual property rights, may even lose future options for doing In-House research. With respect to Contract Models she favours the DESCA Model 1 and its off-springs. These models allow for joint ownerships for all partners. They have the right to licence (unless other agreements were taken) after prior notice and subject to fair and reasonable compensation. Another option is to renounce without further notion. As another reasonable addition she mentions that partners are allowed to transfer foreground with or without further notion and the option for beneficiaries to forbid publication in case of legitimate commercial or academic interests, or the protection of foreground/back ground is affected. With respect to Joint Technology Initiatives she criticises LERU and the German TTO's for demanding the same property rights as industry, not for doing further research but for commercialisation. Albeit, it is problematic that universities also choose being mentioned as a partner in a patent, as soon either a given deadline is passed or the patent procedure is passed to the International Patent Office and in case that the academic part is described as lower than 50 %. Finally she warns that the legitimacy of public funded universities also depend on their public value. Thus universities should do relevant research in case of market failure and collaborate with industry. This means that public money in most cases should be published and be a joint ownership of partners.

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