# WHERE TO GO FOR A CHANGE: THE IMPACT OF AUTHORITY STRUCTURES IN UNIVERSITIES AND PUBLIC RESEARCH INSTITUTES ON CHANGES OF RESEARCH PRACTICES

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## ABSTRACT

*In this article, we analyse how variations in organisational conditions for research affect researchers' opportunities for changing individual-level or group-level research programmes. We contrast three innovations that were developed in universities and public research institutes in Germany and the Netherlands, which enables comparisons both between organisational settings and between properties of innovations. Comparing the development of three innovations in the two types of organisations enables the identification of links between patterns of authority sharing*

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*at these organisations and the opportunities to develop innovations. On this basis, the distribution of opportunities to change research practices among researchers in the two countries can be established.*

**Keywords:** Scientific innovations; universities; public research institutes; Germany; Netherlands; authority distribution

## DO RESEARCH ORGANISATIONS MATTER?

Research organisations significantly contribute to the opportunities for researchers to change their research topics or approaches. Although organisations can exercise only very limited control over the content of their academics' research (Musselin, 2007; Whitley, 2008, pp. 35–36; Whitley & Gläser, this volume), their role as interfaces between society and scientific communities is widely acknowledged. Organisations provide salaries for researchers and resources needed for research. They communicate society's expectations to researchers and useful knowledge as well as cultural contributions by researchers to society. They are therefore important governance actors in their own right, mediators between policy and research, and environments for research. When researchers decide on their future research, they take into account their current conditions of research as well as those they can anticipate for the relevant future, and many of these conditions are shaped by their research organisations.

Thus, while organisations cannot easily *make* researchers change their topics, they can make such changes more or less *likely*. While this influence has been investigated by a number of research strands, there still is a dearth of knowledge about the influence of specific organisational settings on changes in research across different fields of knowledge. Conditions enabling changes in research vary between and within organisations, as do the necessary conditions for such changes in different fields.

A prime example of this variation is the relationship between organisational funding and external project-based funding of research. Since the funding of science in most countries has shifted from recurrent to project-based competitive funding to an extent that makes nearly all empirical research dependent on external grants, it is difficult to compare the differential impact of the two modes of funding on the change of research programmes and practices. Recurrent and project-based funding can be compared, however, when public research institutes based on recurrent funding and universities whose researchers depend on project-based funding are active in the same field.

In this article we consider how variations in organisational conditions for research affect researchers' opportunities for changing individual-level or group-level research programmes. We take advantage of the comparative approach of the RHESI project (see the introduction by Whitley and Gläser in this volume), which studied the development of four innovations in four countries. Three of these innovations were developed in different types of organisations, which enables comparisons both between organisational settings and between properties of innovations.

In the remainder of this article, we first present our theoretical and empirical approach. We then compare the development of three innovations in different types of organisations, and identify links between patterns of authority sharing at these organisations and the opportunities to develop innovations. Conclusions concern the distribution of opportunities to change research practices among researchers in the two countries, advantages and disadvantages of competitive grant funding, and the specific roles of different types of organisations in the development of scientific innovations.

## APPROACH

### *Theoretical Background*

The influence of organisations on the research conducted in them has been investigated from several perspectives. Higher education research is mainly interested in the changing governance of and within universities, while science policy studies focus on the governance of research organisations. Both fields overlap and share a focus on the increasing autonomy of universities and new capabilities to allocate resources, invest in research and teaching programmes, and recruit personnel (e.g. Bleiklie & Kogan, 2007; Clark, 1998; Louvel, 2010; Marginson & Considine, 2000; Sanz-Menéndez & Cruz-Castro, 2003). The few studies of the impact of such changes on the content of research emphasised disciplinary rather than organisational differences between effects (Gläser, Lange, Laudel, & Schimank, 2010; Leišytė, 2007), or are concerned with the consequences for research performance (Jansen, 2010).

Constructivist studies in the sociology of science have observed the importance of organisational contexts for research but, typically being single-case studies, considered only very general aspects of organisational contexts such as the control of organisational resources (Knorr-Cetina, 1981) or the reduction of complexity in hierarchical decision-making (Vaughan, 1999).

There is also a research tradition that directly addresses the impact of organisational conditions on research productivity. Early studies tried to link publication productivity to variables such as group size and group structures (Bland & Ruffin, 1992; Knorr & Mittermeir, 1980; McCarrey & Edwards, 1973; Pelz & Andrews, 1966) and investigated the relationship between organisational control and the autonomy of research (Blau, 1973; Kaplan, 1964; Lambright & Teich, 1981; Zabusky & Barley, 1997). This tradition has been revived by studies that took exceptionally successful research as their starting point and investigated organisational conditions for such research.

In his study of major discoveries in the biomedical sciences, for example, Hollingsworth (2008, p. 231) found that 'major discoveries tended to occur more frequently in organizational contexts that were relatively small and had high degrees of autonomy, flexibility, and the capacity to adapt rapidly to the fast pace of change in the global environment of science'. This was confirmed by Heinze, Shapira, Rogers, and Senker (2009), who additionally found 'creative accomplishments' to be associated with 'small group size, organizational contexts with sufficient access to a complementary variety of technical skills, stable research sponsorship, timely access to extramural skills and resources, and facilitating leadership'. (*ibid*., p. 610).

This brief overview highlights the point that only a few of the many studies of research organisations employ a comparative perspective on organisational contexts or kinds of research conducted in them. Comparing organisational contexts for research requires disentangling a complex net of multi-level causation. In their decisions about research, researchers must take into account not only conditions produced by their organisations but also many influences generating in the organisation's environment, some of which 'bypass' the organisation and address researchers directly. These include interests and preferences of scientific communities, funding organisations, and collaborators, as well as legal frameworks and societal norms concerning research. In order to render these influences comparable and to separate them analytically from organisational influences, we apply two frameworks, one for comparing the impact of governance and one for comparing the micro-conditions for changes of research practices.

The differential impact of governance arrangements for researchers in different organisational environments is compared by analysing *authority relations* concerning the formulation of research goals (Gläser, 2010; Whitley, 2010). An actor's authority is defined here as *institutionally shaped influence* (Schimank, forthcoming). Authority relations, then, encompass the relative authority that can be exercised by members of a configuration of interdependent actors with regard to a specific subject matter (in our case: the formulation of research goals). This notion is both more specific than concepts of governance insofar it focuses on actors (authoritative agencies) and uses institutional structures and processes of governance as 'background information' on how authority is produced and exercised.

At the same time, it is more inclusive than much empirical research on governance because it always includes all actors who have authority concerning a specific decision process regardless of their inclusion in particular governance instruments. This enables the analytical integration of all governance processes relevant to a researcher's decisions. Since bases of authority and the exercise of authority are limited to a few channels – the control of resources, reputation and career opportunities – the relative authority of actors can be assessed, and a comparative framework be formed. This enables comparisons, which in our case means comparing how universities and research institutes are embedded in and modify authority relations concerning the formulation of research goals. In the system of authority relations, research organisations are both an authoritative agency in their own right (an actor with specific interests) and 'channels' for the authority of the organisations' external stakeholders (Schimank, forthcoming).

Our dependent variable is the change of research practices, which we understand as types of actions aimed at producing new knowledge that are characterised by specific theoretical frameworks, objects, methods and objectives. With this definition, we attempt to distinguish between the continuous adaptation of actions to the circumstances of producing new knowledge (Knorr-Cetina, 1981) and changes of one or more of the constitutive elements of a research process (problems, empirical objects or methods). The latter are usually more consequential because they extend beyond a single research project and create new trajectories for research.

Examples of such significant and enduring changes of research practices that diffused in scientific communities include the diffusion of the molecular biology paradigm and practices in cancer research (Fujimura, 1988), the creation of monoclonal antibodies and their subsequent widespread use in the biosciences (Cambrosio & Keating, 1995), the adoption of a new theory as an explanation of new particles observed in high-energy physics experiments (Pickering, 1980) and the emergence of new specialties following from the adoption of new practices (see Edge & Mulkay, 1976 for an overview). These examples have in common that in response to new findings, researchers changed one of the constituting features of their knowledge production and headed off on new lines of research or 'research trails' (sequences of thematically linked projects; see Chubin & Connolly, 1982). Since they affected the practices of many members of at least one scientific community, we call them scientific innovations.

Changes in research practices are very difficult to compare across fields of research due to their idiosyncratic content. However, they can be compared in a framework that focuses on the requirements of such changes. Changes in research practices incur costs and may be risky in several respects. They incur costs because

- they partly devalue the knowledge and equipment a researcher has accumulated working on previous topics,
- a researcher's reputation may suffer if the change requires learning or experimental redesigns and thereby delays opportunities to publish results, and
- the new line of research may deviate from the mainstream of the researcher's community, which again creates the risk of losing reputation.

We use the concept 'protected space' for comparing the opportunities for researchers to pay these costs. Building on Whitley (2012, and in this volume) while adapting his definition for the purposes of our empirical investigation we define protected space as the *planning horizon for which a researcher can autonomously apply his or her capabilities to a self-assigned task*.[1] Dimensions of this variable are the *time horizon* for which the capabilities are at the sole discretion of the researcher (the time horizon for which the researcher is protected from direct external intervention into his or her epistemic decisions and external decisions on the amount of capabilities) and the *resources* (including personnel over which the researcher has authority and time for research). Protected space can be constructed by researchers in a variety of ways, which include interactions with universities and state-funded research institutes and other authoritative agencies. This makes it possible to link the specific protected space required by a change of research practices to the specific authority relations centred on different organisational settings.

Authority relations can be compared according to the protected space researchers can build within them. This includes the shape of protected space (extensions in the time and resource dimensions) and its scope, i.e. the number and positions of researchers who can build protected space that is large enough to enable a change of lines of research. Our investigation focuses on the different shapes of protected space (their extension in the two dimensions) that occur in two types of organisations, namely universities and state-funded research institutes.

## *Empirical Approach*

Our comparative approach includes conditions provided by universities and state-funded research institutes in two countries for three different scientific innovations. For this comparison we could utilise a sub-sample of the cases selected for the RHESI project. Opportunities for cross-country comparisons were limited by the different role of state-funded non-university research institutes in the four national science systems, and within those in different fields of research. Among the countries studied by the RHESI project, only the German and the Dutch national science systems feature state-funded public research institutes and thus enable the comparison.

These two public science systems included in our empirical analysis differ considerably in both size and structure, as is illustrated by Table 1. The German science system is not only much larger but also features a strong state-funded non-university research sector. In the Netherlands, the share of state-funded non-university research is much smaller. Both countries have in common their reliance of experimental research at universities on research council funding. Most university research, and some research at the research institutes, depends on external grants.

The two countries feature different academic career patterns. Germany has a chair system in which all positions below the professorial level are fixed-term positions. The Dutch system has permanent positions below the professorial level. Finally, the Dutch higher education reforms since the early 1980s have considerably changed authority structures in universities by transferring the authority over budgets and staff to universities and strengthening the authority of university managers vis-à-vis academics. In Germany, these reforms began more than a decade later. While the levels of autonomy of universities and the authority of university management have increased here, they are still much lower than in the Netherlands.

We compare changes in research practices that occurred in three different fields, namely the experimental production of Bose-Einstein

***Table 1.*** Key Features of the Two Science Systems Whose Organisations Were Compared.

| Features of Science Systems | Germany | Netherlands |
|---|---|---|
| Size of university sector (billion €)[a] | 11.8 | 4.2 |
| Size of public non-university research sector (billion €)[a] | 7.3 | 1.3 |
| External funding | Essential, most important funding agency is the *Deutsche Forschungsgemeinschaft* (DFG) | Essential, most important funding agencies are the *Nederlandse Organisatie voor Wetenschappelijk Onderzoek* (NWO) and its *Stichting voor Fundamenteel Onderzoek der Materie* (FOM) for physics |
| Key academic positions at universities | Professors (tenured)<br>Assistants (fixed-term) | Professor, *Universitair Docent*, *Universitair Hoofddocent* (all tenured) |
| Key academic positions at research institutes | Director and head of department (tenured)<br>Researcher (fixed-term) | Director (tenured)<br>Group leaders (five-year tenure track)<br>Researchers (fixed-term) |
| Progress of higher education reforms | Since the mid-1990s, limited redistribution of authority | Since the early 1980s, significant redistribution of authority |

[a]Year 2009, sources Federal Ministry of Education and Research (2012, p. 58) and Ministerie van Onderwijs, Cultuur en Wetenschappen (2012, p. 25).

condensates (BECs) in physics, evolutionary developmental biology (evo-devo), and international comparative large-scale assessments of student achievements (ILSA) in educational sciences (PISA being the best-known example). Their key features are summarised in Table 2.

Bose-Einstein condensates are a new state of matter that occurs in atomic gases at temperatures very near to absolute zero (<100 nanokelvin). BECs of cold atom gases were first produced in 1995 by combining several recently developed cooling techniques. The diffusion of the experimental production of BECs began two years later. The production of BECs originally required considerable protected space. Researchers needed to learn several cooling techniques, and to combine them in a new experimental

***Table 2.*** Key Features of the Three Innovations Compared.

| Properties of Innovations | Bose-Einstein Condensation | Evolutionary Developmental Biology | International Large-Scale Student Assessments |
|---|---|---|---|
| Resources required | ~500,000 euros | Up to 1 million euros | Up to 1 million euros |
| Time horizon | Long and unpredictable | Long and unpredictable | Short and predictable |
| Nature of risks | Experimental failure | Experimental failure | No recognition of contributions in scientific community |
| German organisational contexts | Universities and public research institutes | | |
| Dutch organisational contexts | Universities and public research institutes | | Only universities |

setting. The equipment was (and still is) expensive, costing about 500,000 Euros. Building and fine-tuning the experimental system took a long time (at least one and often two years) and required the coordinated work of at least two people. During this time, only few intermediate results could be published. As a consequence, researchers beginning the production of BECs faced the reputational risk of not having significant publications for a long time if the experiments failed. Thus, researchers who wanted to produce BECs needed control of a research group whose research they could direct, of laboratory space in which they could set up their experiment, and of significant additional resources (between half a million and one million Euros) for at least three years.

Evo-devo is a highly heterogeneous life science field which evolved around a set of concepts and questions that explore links between the evolution of a species (the subject matter of evolutionary genetics) and the embryonic development of its individuals (the subject matter of developmental biology). It provides a new perspective on existing data and a distinct set of research questions that require comparative experimental research on genetically different organisms, preferably from two different species. This comparative approach poses a major challenge because most researchers traditionally work with just one species. For the purposes of this comparison we reduce the complex pattern of changing research practices that is described by Laudel et al. in this volume to two strategies: The low-risk strategy entails conducting experiments with the methods and the species the researcher is familiar with and adding a comparative perspective by obtaining information on other species from the literature, through collaboration, or by including model organisms that are already well understood. The protected space required for this strategy is relatively small, but so are the possible reputational gains. The high-risk strategy aims at establishing new species as model organisms and developing new methods. This strategy requires large protected space but also promises higher reputational gains.

Since ILSA cannot be considered an innovation in the Dutch context and was conducted exclusively at universities in the Netherlands (see Gläser et al., this volume), only German researchers at universities and institutes can be included in the comparison. Although ILSA have been conducted for a long time by various international groups, changes in their methodology and organisations significantly improved the comparability of national results and thus mark the early 1990s as an innovative period. In this period German education policy-makers decided to renew Germany's participation in ILSA studies, thereby initiating a process that moved quantitative studies to the core of German educational sciences. This situation implied a major reputational risk for those taking up ILSA. Since the German educational science community did not consider quantitative studies as a legitimate way of doing educational research, it was difficult to see how a standard academic career could be built with producing ILSA data. At the same time, ILSA studies incurred significant material costs. Funding the large groups necessary for the German part of such a study required significant amounts of money (around one million euros).

Taking up ILSA also required being included in one of the international networks conducting the international comparative studies, which in turn strongly depended on having built a reputation and a personal network in the field. Thus, researchers who wanted to be involved in the German part of an ILSA study not only had to cope with a strong unfavourable majority opinion of their community. In order to lead the German part of such a study, they needed to be well connected internationally and to be able to raise funding that was unheard of in this field.

Our analysis is based on documents describing the changes of lines of research at the international and national field levels, interviews with researchers who worked with the innovations or attempted to do so in universities and public research institutes, and background interviews with observers of the fields, officers of funding organisations and university managers. The distribution of these interviews is shown in Table 3.[2]

***Table 3.*** Interviews Conducted in the Two Countries.

| Innovations | Germany | Netherlands |
|---|---|---|
| Bose-Einstein condensation | 9 | 11 |
| – with researchers | 8 | 7 |
| Evolutionary developmental biology | 8 | 16 |
| – with researchers | 8 | 13 |
| International large-scale student assessments | 15 | Not included |
| – with researchers | 11 | |

***Table 4.*** Number of Research Situations Described in the Interviews.

| Innovations | Research Situations | | | |
|---|---|---|---|---|
| | In Universities | | In Research Institutes | |
| | Germany | Netherlands | Germany | Netherlands |
| Bose-Einstein condensation | 9 | 6 | 4 | 1 |
| – changes of research practices | 8 | 5 | 2 | 1 |
| Evolutionary developmental biology | 6 | 12 | 4 | 1 |
| – changes of research practices | 5 | 12 | 4 | 1 |
| International large-scale student assessments | 14 | Not included | 16 | Not included |
| – changes of research practices | 4 | | 8 | |

Interviews with researchers focused on the position of the epistemic switch in the interviewee's research biographies and on the necessary and actual conditions for that switch. Owing to the small size of the Dutch scientific communities, all researchers who took up BEC and evo-devo in the Netherlands could be approached and interviewed. In Germany, we approached all researchers who could be identified as having taken up BEC in the 1990s, all researchers who led projects producing ILSA data since the early 1990s, and a sample of researchers who began evo-devo research early (in the 1980s or 1990s). Two German BEC researchers declined to be interviewed.

The cases that form the basis of our analysis are distinct situations in which our interviewees built protected space at universities or public research institutes. The research situations include those in which interviewees attempted to change their research practices by moving to one of our three innovations and those in which they already worked with the innovations, and to which they referred for comparisons (Table 4). The number of these situations often exceeds the number of interviewees. The mobility of researchers included moves between organisations (e.g. from a research institute to a university) and moves between key academic positions (e.g. if a German assistant or a Dutch *Universitair Hoofdocent* became professor). This is why the number of cases we could analyse is larger than the number of interviews conducted. Not all attempts to change research practices were successful. The situations include researchers in all key academic positions at both types of research organisations, which is why we are confident that the typology of research situations they described is exhaustive.

## BEGINNING NEW LINES OF RESEARCH IN DIFFERENT ORGANISATIONAL SETTINGS

### *Bose-Einstein Condensation*

In spite of the differences between German and Dutch *universities*, the situations of university researchers who wanted to move to BEC research in the two countries were quite similar. German university professors could construct the necessary protected space if they already had the basic infrastructure for producing BECs, namely a laboratory that was equipped for cooling atoms or working with lasers. The first two German researchers who produced BECs were university professors who had part of the necessary infrastructure already in place because their previous research was methodologically similar to BEC. Two other researchers had used their postdoctoral positions abroad to learn the methods for producing BECs. When they returned to Germany and were appointed professors, they used their start-up packages to equip their laboratories for producing BECs. Four other professors used loyalty negotiations to acquire the funding for the new equipment.[3] In all cases, start-up or loyalty packages bought the major equipment and recurrent funding for one or two positions, which almost covered the workforce requirements for producing a BEC.

However, recurrent funding was never sufficient to purchase the expensive equipment or to pay the running costs of the laboratory.

> I've got something like one million start-up funds from my appointment negotiations, which was relatively high, but the recurrent resources are negligible. It is about 40,000 Euros. Half of it, 20,000 Euros, is spent for the machine workshop, telephone and copies, something you need anyway. These 20,000 Euros are a tiny fraction of what it [running the equipment] actually costs. (university professor)

The costs of actually running the equipment (which included costs of additional personnel) had to be covered by external funding. This created a contradiction between the standard time span of grants (three years) and the time span necessary to produce BEC, which was impossible to predict and often was longer than three years. However, it turned out that intermediate results were accepted by the reviewers of the DFG and other funding agencies. This attitude guaranteed continuing access to grants, which compensated for grant cycles that were too short for producing BEC (see Laudel et al., this volume; Gläser et al., 2014). This willingness of funding agencies to support BEC continued unchanged. Nevertheless, the 'grant business' could delay the progress of research for months. This endangered the position of German university professors in the international competition, which in some cases took the form of 'races' for BECs of specific atoms.

Given this description of situations of German university professors, it comes as no surprise that only one researcher below the professorial level at a university tried to switch to BEC. At this time, he had no discretion over recurrent funding or PhD students, who were all hired and supervised by professors. The overall time horizon of his research was determined by a fixed-term position of five years. This small protected space increased in the resource dimension after the researcher received a large grant for junior research group leaders from DFG.

> Then I got an Emmy Noether grant of about 350,000 Euros. Ultimately, that was the lion's share of the material investments. The whole infrastructure was provided by [my professor]. I also had a PhD student from his university budget.

Although this grant bought the (low-budget) equipment, moving to BEC experiments still depended on the permission and support by his professor. It is impossible to say whether the protected space was sufficient in the time dimension because the researcher was appointed professor at another university before he achieved BEC as a junior research group leader. He used his start-up package from the new university to build a new experimental system for BEC.

Despite the different university structures, the description of the German situation applies to Dutch BEC experiments, too. Although Dutch academics below the professorial level have tenured positions, they have no control of the technical infrastructure for research or access to PhD students. Professors control the infrastructure of laboratories, and share authority over recurrent funding and PhD students with faculty management. In the case of BEC, this control mattered because as in Germany, all moves to the production of BECs at universities ultimately depended on decisions by professors.

The situation of Dutch university professors also resembled that of their German colleagues in that they depended on external funding when building their BEC experiments. Their recurrent funding paid for the basic infrastructure of a laboratory, one or two PhD positions, and technical workshops at the universities that could be used to custom-build experimental equipment. Specific equipment, consumables and additional personnel had to be funded from external grants. The time horizons provided by the grants were better (four years) but the community's tolerance of delays in outcomes was lower (see Laudel et al., this volume).

The authority of professors over the resources provided by the university becomes apparent if we look at three academics below the professorial level who attempted to begin the production of BEC. Two of them became interested in BECs soon after the first experimental successes but could not pursue this interest because their professors did not approve. One of them was in a situation that exactly mirrored that of the German junior research group leader quoted above: He received a large grant that paid most of the costs of BEC research but was not large enough to pay for the infrastructure, too. Only when he was appointed on an independent tenure-track position and received a start-up package from his university could he finally undertake the production of BECs. A third academic could change his research because his professor tolerated the change and granted access to his infrastructure for these experiments. Although two of the non-professorial researchers had tenured positions and thus a long-time horizon for their research, and all three had the opportunity to independently apply for external funding, their dependence on their professor's infrastructure was decisive for their opportunities to build the protected space necessary for the production of BECs.

Directors at German *public research institutes* (directors of the institutes and heads of departments) had in common with university professors their complete freedom of choosing research topics and the long-time horizons of their permanent positions. They had a considerable advantage over their colleagues at universities, however, because the recurrent funding of the institutes was sufficient to conduct BEC research without any additional external grants. While the same amount of resources can be amassed by university professors from external grants, the recurrent funding saves time and lowers the risk of interruptions by failed grant applications, as a researcher who worked both at a university and public research institute explained:

> Let's put it this way, with regard to my financial situation I actually had the same financial resources. I do not have more money now than I had, for example, at [university A]. I had excellent funding [at university A], which was as good as now [in the public research institute]. You can have in Germany, in Europe, an outstanding financial support. But of course I had to do much more for it. I spent a lot more of my time on administrative work. The time I spent on writing applications I can now spend on physics.

Among the three interviewed directors at public research institutes was one who had started BEC research as PhD student and followed this line of research over his whole career, i.e. did not need to change his research practices. A second director changed his research to BEC without needing to acquire external funding. A third director did not change his own direction but acted as sponsor, i.e. enabled the change of research by a researcher in his department. This researcher's protected space was still small because of the missing autonomy and limited discretion over resources. He had to ask for money but was supported by this director. He immediately received some money from the director's recurrent budget for altering the experimental system.

> Well, more money … went into [the director's] main activity …. But there was some surplus money. And that we could kind of use (or convince him to by) this and that. So I remember that at some stage, I wrote a one-page letter to [the director], whether he would have 50,000, Deutsche Mark I suppose, and then I could change my experiment to a BEC experiment.

Since the money available ad hoc from the director's budget was not sufficient, the researcher had to apply for additional grants for the necessary modifications of the experimental system and for recruiting an additional PhD student. However, he could immediately begin to reconfigure the existing equipment while he waited for the grant to be approved.

The situation at the Dutch public research institute was markedly different. The institute was funded by the funding agency for the physical sciences, FOM, with the mission to explore new directions of research. Its mission and themes are controlled by the Dutch physics community, and funding is partly conditional on the approval of research programmes by FOM. The director of the institute is primarily a manager whose time for research is limited. The institute consists of research groups that are headed by researchers who are appointed to five-year tenure-track positions. They rarely stay at the institute for more than 10 years because they move to university professorships.

In 1996, the elite of the physics community, which was represented in the FOM board, decided to reduce research in nuclear physics and to establish biophysics as new research field at the institute. Biophysics was considered underdeveloped in the Netherlands at that time. The board expected half of the institute's research to be biophysics by 2006. As a consequence of this thematic reorientation, the director of the institute, an internationally leading BEC researcher, decided to keep only a small group for BEC research, and to orient the other groups towards biophysics.

While the director could use the excellent infrastructure and basic equipment provided by the institute, the institute's recurrent funding was not intended to be the sole basis for research, and was not sufficient to produce the protected space for producing BECs. The director and group leaders had to apply for grants with FOM, the same agency that provided the institutional funding for the institute.

> And [the institute] … normally the groups were relatively small, maybe three or four PhD students per staff, that was the maximum. On my CV it would say external grants. And I would say half was effectively … internal grants and half was really earned on my merit and writing something original.

### *Evolutionary Developmental Biology*

The possibility of entering the evo-devo field with low-risk strategies let many researchers at *universities* gradually move to evo-devo by stepwise increasing their commitment (see Laudel et al., this volume). Most of them also kept other lines of research besides evo-devo. This was in principle possible for professors as well as researchers below the professorial level. For example, two German interviewees moved to evo-devo after they were already appointed as university professors, and have mainly worked on low-risk projects ever since. Another researcher began evo-devo research when he was a postdoc but decided to move to the high-risk strategy when he was appointed to his first professorial position. The decision went hand in hand with the winning of a research prize that substantially increased his start-up funds.

German professors who wanted to conduct experimental evo-devo research needed start-up or loyalty packages for establishing an evo-devo laboratory and for establishing breeding facilities regardless of the riskiness of their strategies. Owing to the modularity of the research problems and experiments (which is different from the production of BECs), researchers could partially overcome limitations of their own resources by sharing equipment and staff with neighbouring research groups. The large university landscape of Germany made access to a wide range of data sources and/or expensive equipment relatively easy. However, the high costs involved in developing the high-risk strategy of evo-devo research, caused by the required breeding facilities for multiple new species, appear to have exceeded the opportunities of university start-up and loyalty packages. We found no university professor who engaged in such a strategy (see Laudel et al., this volume).

Even for low-risk experimental evo-devo research, all university professors were dependent on external funding sources (prizes, project grants, etc.) to create sufficient protected space for experimental evo-devo. Universities' recurrent funding is usually not sufficient to pay even the maintenance of the laboratory.

> Well, the university supported us here, so to speak, by paying electricity, paying the telephone, paying for the heating and for the paper for the copy machine. (university professor)

All German researchers below the professorial level who changed their research practices started their evo-devo careers by adopting model organisms and tools that had already proven their usefulness in other specialties. Their cases indicate that starting evo-devo is possible in early career stages. But again, all PhD students and postdoctoral fellows relied more or less on the goodwill of their supervisors or heads of laboratory, who had to grant them the use of infrastructure for their evo-devo research.

Despite the shortages of recurrent funding, the evo-devo field is growing fast since the late 1990s. One interviewee estimates around 500 researchers in Germany who actively participate in today's evo-devo conferences. The reason given by all interviewees for the 'explosion' of evo-devo approaches is the funding policy of the DFG, which still provides funding for investigator-driven basic research despite global and national trends of expecting medical applications from the life sciences.

> It is not very easy in the evo-devo field, because it is not medical, not applied research. It is always easier to get money for these areas, because there exist pre-formulated research programmes for which you can apply, we do not fit into these. We always

have to apply for programmes that provide complete freedom in terms of content. Classically, this is provided only by the DFG's Individual Grants Programme.

In the Netherlands, the opportunities for building protected space at universities are again similar to those in Germany. Owing to the variety of strategies with which costs and risks of evo-devo research can be controlled, both professors and other researchers moved to evo-devo research at various stages (see Laudel et al., this volume). After evo-devo was originally considered important enough by the community to warrant the creation of a chair at one university, increasingly specific demands of state policies concerning university profiles, changing criteria for grant funding and the strong authority of Dutch university management worsened the situation of evo-devo researchers at universities from the mid-2000s.

The basic research character of evo-devo research, its limited access to highly ranked journals, the resulting difficulties to attract grant funding and its distance from the national priorities for research made evo-devo research unattractive for universities. The problems with research funding can be traced back to new priorities of the Dutch national research council NWO. Grant funding from NWO has been losing its independence from political expectations. Today, an orientation towards applications and national priorities is increasingly important for proposals to be successful. As a result, evo-devo research has largely disappeared at Dutch universities, and only a few scattered researchers engaged in some kind of evo-devo research remain (see Laudel & Weyer, this volume).

German researchers at *public research institutes* could often move to evo-devo research without applying for external funding at all, and were able to apply high-risk strategies. This happened in four cases reported by our interviewees. Two researchers decided to move to evo-devo research when they were directors at institutes, while the others had already moved to evo-devo at their universities, and brought their evo-devo research with them when they were appointed directors at institutes. Of the two directors who changed their research, one recruited a researcher for this purpose. This researcher was the only German interviewee who chose to enter the evo-devo field with a high-risk strategy. The risk remained manageable because he was a member of a large research group and was backed by his director. The other director strongly supported the move to evo-devo by groups at his institute. In both cases, no external funds were necessary.

All four research institutes have an excellent infrastructure, and directors can direct the research of several staff members (technicians, PhD students, and postdocs). Researchers at public research institutes usually followed more risky and time-consuming research lines than their colleagues at universities. The relatively large group size (at least 20 researchers) allows directors to spread the risks of developing new tools and/or model organisms among several individuals:

> The dilemma you are confronted with is: If it [the experiment] works, the person who is responsible got a project. If it doesn't work, you try for some time, but in this case the researcher needs a back-up project to successfully finish his PhD or to get some results from his postdoctoral work. (director, research institute)

Such 'back-up projects' are very common in large research institutes. They exist at universities as well, but here 'back-up projects' depend on the successful acquisition of several parallel grants. Another advantage of research institutes is that directors and heads of laboratories are not bound to the short-term time horizons of project grants. On the basis of large and continual amounts of recurrent funding, they can plan high-cost research lines that will pay off in terms of reputation only after five or even ten years. For example, some new ecological approaches in evo-devo require expeditions to collect new organisms and the establishment of field laboratories abroad. These tasks can be afforded by research institutes but not by university professors who depend on the Individual Grants Programme of the DFG.

In the Netherlands, one public research institute is a potential host for evo-devo research. Authority relations at this institute, which is funded by the Dutch Academy of Science, are similar to those of Max Planck Institutes and some Leibniz Institutes in that the directors of the institute can autonomously determine the institute's research agenda. However, similar to the physics institute funded by FOM, the bioscience institute provides only limited recurrent funding. Group leaders receive funding for technical support and one PhD position, and are expected to apply for external grants for their research. Again, the situation of group leaders is similar to those of university professors.

The Dutch institute has a strong tradition in developmental research and was therefore a potential host for evo-devo research. However, the directors of this institute decided not to include evo-devo research in their research agenda and recruited more and more groups from other research areas. Thus, the basis for evo-devo research gradually vanished.

### *International Large-Scale Student Assessments*

In the early 1990s there were few professors at German *universities* who conducted quantitative empirical educational research. The study of the conditions leading to educational success was dominated by qualitative approaches derived from the humanities, and neglected the measuring of competences (cf. Fend, 2010, pp. 286–290; Zedler & Döbert, 2009, pp. 24–28). As a consequence, the first researchers who wanted to change their line of research towards ILSA were also pioneers of quantitative comparative empirical educational research in Germany. It was only in response to the outcomes of the first German ILSA studies in the late 1990s that more professorships for (quantitative) empirical educational research were created, a process which has continued ever since. These professorships provided the protected space for the change of research to ILSA, and secured careers in the context of reputational risks. Since a professor's infrastructure was limited, the large investments necessary for ILSA research projects could only be made with external funding, which in the case of ILSA was provided by the state. Accessing this external funding required seed-funding for preparatory activities, which put university professors at a disadvantage.

> … these 80.000 Euros without which you could not have done the preparatory work within the international network. All these things had to be decided and done relatively quickly. If I had had an application processes with the EU and external peer review and BMBF and such things, nothing of this would have happened …. International things sometimes run very fast and a decision must be made somehow within one or two weeks. Then you are either in or out.

When the professor who described this problem first applied for leading a study, he solved the problem of missing seed-funding by asking colleagues from a public research institute to 'lend' him the necessary money. He then could acquire the external funding for the study from the state, i.e. by circumventing the peer review of the potentially hostile educational science community. The state was willing to grant funding because it was interested in the results of ILSA studies. With these grants, university professors could expand their research capacity. Thus, university professors simultaneously had protected space that was small in the resource dimension (recurrent funding) and long in its time horizon (permanent autonomous position) and protected space created by grants that was somewhat larger in the resource dimension but limited in its time horizon.

At the beginning of the diffusion of ILSA studies in Germany, no university positions below the professorial level were available for work on this topic. The established educational research professors did not hire assistants for ILSA studies because they disliked this kind of research. As a consequence, no protected space was available for non-professorial academics, and no change of lines of research was possible for them.[4]

Given the conditions at universities, it comes as no surprise that ILSA studies were first taken up by German *public research institutes*. Three of these institutes had been set up with the mission to conduct empirical educational research, which made them the natural place to conduct ILSA studies, and gave the directors at the institutes little opportunity to decline such an involvement even if they wanted to (see Gläser et al., this volume).

The directors at public research institutes who changed their lines of research benefited from a large protected space with sufficient resources and long-time horizons. They had authority over significant recurrent funding and positions, which made it possible for them to form the large consortia required for conducting ILSA studies in Germany. The seed money for preparing the participation in future studies was easily available from recurrent funding. The external funding for conducting the studies could be acquired from the state due to the latter's interest in the results and due to the reputation of the institute. Regular contacts with national and international elites are easy to maintain for a director at an institute. A researcher who worked in both types of organisations highlighted the differences:

> I can just easily, without thinking about it, fly to America with two people and can get the information from an internal meeting of the organisation that conducts the study. That costs a couple of thousand Euros, and I don't have to think about it. A normally funded professor could not do all this. This is easy for someone who has a research institute but close to impossible for someone with a regular university chair, who cannot do this kind of studies.

For the directors, institutes provided much better conditions for switching than universities did for professors. Especially the university professors' lack of access to seed-funding, which is necessary to fit into the tight international time schedule of ILSA studies, created a huge barrier for ILSA research at universities. Consequently, one director at a public research institute declined a professorial appointment at a university. He wanted to move to that university for personal reasons but ultimately didn't because he believed his ongoing ILSA research could only be conducted at a public research institute:

> That was a very hot time where I thought I could not take this with me, that would not work. You can do this only in [institute], with these resources.

From the other perspective, a university professor explains why he ceased his involvement in large studies:

> … these large studies have grown to a size that you cannot handle as a normal university professor with two or three assistants. You need a lot of additional resources …

The protected space for staff at public research institutes was not limited in the resource or networking dimensions. Working on full-time research positions, researchers below the level of a director had a large research capacity as well as opportunities to learn about the new methods and new research objects. Although they depended on the institute's director, they were provided with sufficient resources because the director decided to establish the group:

> And there was really no restriction of resources. When I arrived there I asked [the institute's director]: "What about the budget for the library?" He looked surprised and said: "How? What? You don't have a budget. What you want to buy, you simply buy." And then I asked: "What about student assistants? How much money can I spend on them? How many thousands?" "We don't have budgets. You get what you need."

The time horizon of the protected space of researchers was limited by fixed-term positions. Even researchers on permanent positions below the level of a head of department were expected to leave the research institute after the *habilitation* and to move to a professorial position at a university.

Researchers at public institutes who were not directors could not autonomously choose their research topics. They had no discretion over recurrent funding and few opportunities to acquire grant funding independently. Owing to their fixed-term positions, their opportunities to conduct research that is risky in reputational terms (delayed publications, no publications at all) were very limited. If they wanted to conduct ILSA studies, however, they had access to the necessary resources and international contacts. This is why research institutes might not have provided better conditions for solitary changes of research practices but certainly provided better conditions for such changes *when the new practices already were represented by a director*.

## PATTERNS OF AUTHORITY SHARING AND OPPORTUNITIES TO CHANGE RESEARCH PRACTICES IN TWO TYPES OF RESEARCH ORGANISATIONS

The comparison of situations of researchers who wanted to change their practices by developing an innovation makes it possible to identify characteristic patterns of authority sharing, which enable specific protected space to be built and thus create distinct opportunities to change research practices. We will do this in three steps. First, we describe the patterns of authority sharing we observed in our comparative case studies. Thereafter, we link patterns of authority sharing to opportunities to build protected space for the change of research practices. In a final step, we discuss the distribution of these patterns in the two science systems.

## *Patterns of Authority Sharing*

Five distinct patterns of authority sharing by researchers can be identified in terms of which authoritative agencies enabled the building of protected space, and thus with whom researchers shared authority over their research goals (Table 5). First, *full authority* of researchers over research goals was observed in some German public research institutes, where directors did not have to share their authority at all. This pattern is created by the state granting sufficient recurrent funding for the institute's research and relinquishing its authority over the uses to which these resources are put. Researchers who have full authority can build almost any protected space that might be necessary in their field. They have full discretion over the necessary resources, and enjoy long-time horizons due to their permanent positions at research institutes. The institutes themselves are regularly evaluated but can be assumed to exist for a long time.

Second, *mission-bound full authority* was observed at German public research institutes whose directors also have full discretion over a large amount of resources but are bound by their institute's mission. If the state

***Table 5.*** Patterns of Authority Sharing.

| Authority Pattern | Authority over Research Goals Shared between | | | | |
|---|---|---|---|---|---|
| | Researcher | State | Scientific community | Management | Senior researchers |
| Full | X | | | | |
| Mission-bound full | X | X | | | |
| Community-shared | X | | X | | |
| Embedded community-shared | X | | X | X | |
| Enmeshed | X | | X | X | X |

voices expectations that fall within the scope of its mission, institute directors have little choice and need to organise a change of research practices with at least some of the institute's resources. Mission-bound authority means that researchers have to adapt to expectations of authoritative agents who, however, do not intervene in the formulation of research goals or selection of approaches. Researchers who have this authority can also build most protected space that might be necessary in their field.

Third, *community-shared authority* is a pattern that is characteristic for German university professors and group leaders at the two Dutch institutes. After they are appointed, these academics have full discretion of their recurrent funding. Since this funding is insufficient for experimental research, however, they need to supplement it with grants, which are controlled by their scientific community. This makes any change of research practices and particularly the switch to a scientific innovation dependent on the decision practices and epistemic preferences of the community (Gläser et al., 2014). We speak of shared authority if researchers need to negotiate goals or approaches with other authoritative agencies. Due to the esoteric nature of the knowledge required for competent negotiations, authority is likely to be shared with peers, i.e. with researchers from the same field.

Fourth, *embedded community-shared authority* is the authority of researchers who not only share their own authority over research goals with their community but also find this authority sharing embedded within their organisational environment, which constrains their authority. We found two versions of this embedded community-shared authority in the Netherlands. First, university professors today share their authority with the university management which, although unable to influence the use of the recurrent funding by professors directly, has discretion over the existence of a professor's field of research at the university, and can grant or withdraw recurrent funding. As the example of Dutch evo-devo research demonstrates, the university management (university leadership and deans) can strengthen, limit, or discontinue the presence of fields at the university. The shared authority of Dutch university professors is contingent on this particular authority, a relationship that becomes apparent only in specific cases (see Weyer & Laudel, this volume, for more examples). Second, a similar embedded community-shared authority characterised the situation of the director of the Dutch physics institute, who enjoyed an excellent research base but depended on his community for grants *and* found himself embedded in a decision process of the agency that funds the institute about the latter's research programme.

Finally, *enmeshed authority* is a pattern encountered by all researchers below the professorial or director level at universities and public research institutes in both countries. These researchers had to share their authority over means for building protected space with many others. They had no discretion over infrastructure and thus depended on senior researchers in the organisation (their professors or directors) who could grant them access to infrastructure. They had to share authority over their research goals with the senior researchers, which also embedded them in the latter's authority relations. If they needed additional grants, they had to share authority with their communities.

### *The Impact of Authority Patterns on Opportunities to Change Research Practices*

These five authority patterns are linked to different opportunities for building protected space, in terms of both resources and time horizons, and to opportunities for changing research practices, which we compare in terms of the limitations under which the authority patterns operate (Table 6). Full and mission-bound full authority patterns have in common that researchers have discretion over the resources necessary for virtually all

***Table 6.*** Impact of Authority Patterns on Opportunities to Build Protected Space and to Change Research Practices.

| Authority Pattern | Opportunities to Build Protected Space | | Limitations of Protection |
|---|---|---|---|
| | Resources | Time horizon | |
| Full | Available as needed | Long | None |
| Mission-bound full | Available as needed | Long | None within bounds of mission |
| Community-shared | Contingent on approval of grants | Split | Delayed, rarely insufficient |
| Embedded community-shared | Contingent on support by university and approval of grants | Split | Delayed, occasionally insufficient |
| Enmeshed | Contingent on permission by senior researchers and approval of grants | Split or fixed-term | Delayed, insufficient in most cases |

protected space that might be necessary in their field, and enjoy the long-time horizons of permanent positions and the tenure of their institutes. The boundaries set by missions of institutes are likely to matter only in very rare cases.

The community-shared authority pattern provides only limited opportunities to build protected space. It is contingent on grants (the acquisition of grants and their size) in the resource dimension. In the time dimension, protected space is split along the two sources of resources, i.e. between the long-time horizons of permanent discretion over some recurrent funding and the time horizons of grants that are necessary to supplement recurrent funding. These conditions do not necessarily constrain the opportunities to change research practices. However, the building of protected space is delayed by the grant approval process if the community and the funding agency do not tacitly accept the use of awarded grants for research on problems for which they were not awarded. There are also cases in which the community enforces its majority opinion that some changes of research practices are not worth funding, as the Dutch physics community did in the early phase of experimental BEC research. In these rare cases, the community-shared authority pattern is insufficient.

The embedded community-shared pattern enables the same building of protected space as the community-shared pattern but is additionally contingent on the acceptance of a research field by the university, and might require additional negotiations of the thematic scope in which protected space can be build. It is therefore likely to be insufficient more often than the community-shared pattern.

Enmeshed authority made changes of research practices dependent on the acceptance of professors or directors, contingent on the authority structures these gatekeepers were embedded in, and in most cases also contingent on the decisions within the scientific communities. The resources that could be mobilised with it were contingent on both the contributions by senior researchers and the grant decisions in the scientific communities. Time horizons were either limited to fixed terms or split. In Germany, a fixed-term time horizon is associated with this authority pattern because the fixed-term grants are combined with fixed-term positions of researchers. This also applies to some of the Dutch researchers below the professorial level, particularly to those whose positions are funded by fellowships. The regular Dutch university positions below the professorial level – *Universitair Docent* and *Universitair Hoofdocent* – are permanent positions, which creates split time horizons. As a result of the multiple dependence, limitations to building protected space are common, which in turn means that this authority pattern only rarely supports changes of research practices.

### *Distribution of Authority Patterns in the German and Dutch Science System*

Having identified the ways in which the different authority patterns affect the opportunities for changing research practices, we now need to identify their distribution throughout the two national science systems. Table 7 lists the empirical cases we found and used to identify the authority pattern and conclusions about the distribution of the patterns.

The range, or scope, of situations in which the full and mission-bound full authority patterns occur is small because there are very few positions in German public research institutes whose incumbents enjoy such relatively untrammelled authority. They are also not available in all fields of science, which is why it is only by chance that a potential innovation can be supported by this authority pattern.

The scope of community-shared authority patterns is medium in Germany, where it includes all university professors, and small in the Netherlands, where it includes only directors of research institutes. It is further limited by the infrequent situations in which German university professors can build protected space for more radical changes of research

***Table 7.*** Distribution of Authority Patterns in the Two Countries.

| Authority Pattern | Observed Cases | | | Distribution |
|---|---|---|---|---|
| | BEC | Evo-devo | ILSA | |
| Full | Germany | Germany | | Only in Germany, very few |
| Mission-bound full | | | Germany | Only in Germany, very few |
| Community-shared | Germany<br>Netherlands | Germany | Germany | Medium in Germany (professors), very few in the Netherlands (directors of institutes) |
| Embedded community-shared | Netherlands | Netherlands | | Medium in the Netherlands |
| Enmeshed | Germany<br>Netherlands | Germany<br>Netherlands | Germany | Widespread in both countries |

practices, namely appointment and loyalty negotiations. Only in these situations can the inert part of their protected space – the infrastructure and basic equipment that are paid for from recurrent funding – be shaped differently to support new research.

Embedded community-shared authority patterns also have a medium scope because they occur for all Dutch university professors. However, the latter have better opportunities to negotiate ad hoc funding for changes in their infrastructure due to the increased authority of university management over resources. The most common authority pattern in both countries is that of enmeshed authority. It was found with all researchers below the professorial level at German and Dutch universities.

If we compare the distribution of authority patterns in the two countries, interesting commonalities and differences become apparent. First, opportunities to change research practices are largely restricted to 'professors and above' since building protected space in the experimental sciences depends on access to infrastructure, and authority granting this access is restricted to professors in both countries. Second, Dutch university reforms have not modified the distribution of authority between professors and nonprofessorial academics at universities. Possibly due to the overall scarcity of recurrent funding, this funding is still concentrated on professors. At the same time, university reforms did modify the authority distribution between professors and the university management. Authority over the existence of fields at universities is now shared with the management, with the latter having a veto position in this particular decision process (see Weyer & Laudel, this volume). This creates an embedded community-shared authority pattern that does not yet exist in Germany. Third, Dutch public non-university research institutes provide authority patterns resembling those of Dutch university professors rather than being an alternative to them. This is why the characteristic authority patterns that can be provided by public research institutes – those that make researchers fully independent from other authoritative agencies – do not appear to be firmly institutionalised in the Netherlands, which points to a different national pattern of authority sharing (Gläser et al., 2014).

## CONCLUSIONS

Protected space enables changes of research practices because it provides autonomous discretion over resources for a specific time horizon, which also suspends reputational consequences of not meeting expectations of the community for that time (for the latter, see also Hackett, 2005). The opportunities for researchers to build such protected space depend on authority patterns in their research organisations. We could identify five distinct authority patterns and trace their distribution across the national German and Dutch science systems. Our analysis leads to four conclusions.

First, opportunities to change research practices are very unevenly distributed in the two national science systems. The majority of researchers face an enmeshed authority pattern, in which building protected space depends on too many authoritative agencies to have high changes of success. In both countries, professors have opportunities to build protected space and act as gatekeepers because they control the infrastructure at universities.

Second, the community-shared and embedded community-shared authority patterns, which we found for professors, may delay the change of research practices and introduce additional risks compared to full authority patterns. The early changes to BEC in German universities do not invalidate this conclusion because the researchers in question had already built a resource base and needed only few additional resources once the possibility of producing BECs was demonstrated.

Third, the full and mission-bound full authority patterns provide a significant advantage both with regard to immediate and unconditional access to resources and protection from reputational consequences if a change of research practices contradicts the community's current majority opinion. It is quite difficult to base the decisive stages of one's career on research contradicting the mainstream (and proved impossible in the case of ILSA at German universities). It became possible in universities only after research conducted at public research institutes established the field.

Thus, our analysis points to the necessity of being able to build protected space quickly without needing the agreement of other authoritative agencies in the early stages of the diffusion of new research practices, which includes the original scientific innovation. This underlines the importance of full authority patterns for flexible responses to new developments on the micro-level even though the grant funding on which community-shared authority patterns are based may provide a more flexible national-level system.

Fourth, the empirical findings appear to prove the superiority of block funding as a condition for major changes in research practices. While this might well be the case (and further research is needed to make this point more firmly), the conclusion that block-funded public research institutes are a solution to the problems of grant funding would be premature. Even in Germany with its large sector of public research institutes, these institutes do not cover all fields, and thus cannot foster innovations across the full spectrum of scientific disciplines. There are also several important reasons why universities will always play a key role in the diffusion of scientific innovations even if these innovations are created in other organisational settings. First, universities still offer more career opportunities for researchers because there are many more positions for both young researchers and professors. Research institutes do not provide positions for researchers from all fields, and provide significantly fewer positions for both young researchers and directors if there is a research institute for a field. Second, the involvement of academics at universities means that new practices may diffuse to teaching. Third, academics at universities have the best access to promising PhD students. Last but not least, only universities can grant PhDs and thus the entrance into research careers. Owing to this strong position in academic career patterns, universities are 'obligatory points of passage' (Latour) in the diffusion of any scientific innovation, which makes them a limiting factor if they cannot sufficiently contribute to the protected space for their researchers.

## NOTES

1. The idea of 'protected space' has been previously used by Rip (1995, p. 86) to describe the laboratory as a space in which researchers are shielded from interference (see also Krohn & Weyer, 1994). Rip and others have also used the concept for describing a situation that is necessary for the early development of technological innovations (Kemp, Schot, & Hoogma, 1998; Rip & Schot, 2002). Rip has recently extended the concept to 'protected spaces of science' in society (Rip, 2011). Our use of that concept deviates from Rip's in that we define it at the micro-level of individual researchers and their projects, include the protection from reputational consequences in the scientific community, introduce the time horizon for which a researcher is protected, and link it to the macro-level by asking for whom these individual-level protected spaces are provided.

2. We would like to thank Raphaël Ramuz for providing access to one of the interviews he conducted, which is relevant to the German case.

3. German university professors receive money for initial investments in their research and teaching infrastructure on appointment (start-up packages) and for additional investments when they negotiate staying with their university after being offered a position elsewhere (loyalty packages).

4. In order to make sure that this observation is not an artefact of our selection of interviewees, we searched the German LSA community for researchers that might have switched at a German university in the 1990s and were not professors. We are sure that this didn't happen.

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