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Beyond breakthrough research: Epistemic properties of research and their consequences for research funding

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ABSTRACT

The aim of this paper is to initiate a discussion about links between epistemic properties and institutional conditions for research by providing an exploratory analysis of such links featured by projects funded by the European Research Council (ERC). Our analysis identifies epistemic properties of research processes and links them to necessary and favourable conditions for research, and through these to institutional conditions provided by grants. Our findings enable the conclusion that there is research that is important for the progress of a field but is difficult to fund with common project grants. The predominance and standardisation of grant funding, which can be observed about many European countries, appears to reduce the chances of unconventional projects across all disciplines. Funding programmes of the 'ERC-type' (featuring large and flexible budgets, long time horizons, and risk-tolerant selection processes) constitute an institutional innovation because they enable such research. However, while the ERC funding and other new funding schemes for exceptional research attempt to cover these requirements, they are unlikely to suffice.

1. Introduction

If funding is a lever for science policy to steer research: How does this lever work? More precisely: Which properties of funding arrangements promote one kind of research and discourage another? And which kinds of research should be distinguished in an answer to the previous question? These questions have gained enormous political significance over the last decades because science has grown so costly that it has become an asset that needs to be very carefully managed.

The questions also point to one of the topics of science studies about which our knowledge is rather thin and scattered, namely the link between the content of research and the institutional forms in which it takes place. Any attempts by science policy to change the content of research are mediated by researchers' or research groups' selections of research problems, objects, and approaches. Researchers are an 'obligatory point of passage' (Latour) for the governance of research content (Gläser, 2012). In order to understand how the direction of research can be changed at all, and how specific changes are achieved, we need to understand the properties of research processes that make the latter susceptible to governance.

The importance of this question has been acknowledged for a long time. Organisational conditions and the wider conditions shaped by science policy need to be included by the sociology of science in order to fully understand how scientific knowledge is constructed (Knorr-Cetina, 1981), although laboratory studies continue to have difficulties in systematically including macro-social structures such as institutions (Knorr-Cetina, 1995: 160–163; Kleinman, 1998: 285–291). In the reverse perspective, understanding the impact of governance on research content requires systematic comparative studies of this content, which poses methodological challenges to science policy studies (Mayntz and Schimank, 1998). Thus, neither the sociology of science nor science policy studies can advance their major explanatory project without exploring the link between institutional conditions (or, more generally, governance) and the content of research.

Contributions to the analysis of links between governance and research content have been addressed at several levels including the level of national science systems, at which the link between governance and the content of research is addressed only in a very general way (e.g. Rip, 1994; Braun, 1998; Whitley, 2003), studies of specific organisational forms such as research centres at universities, which emphasised the opportunities for interdisciplinary research (Myers, 1993; Groenewegen and Peters, 2002)

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and technology transfer (e.g. Feller et al., 2002), and studies of the impact of university-industry links on research content through conflicts of interest (e.g. Stelfox et al., 2003), a willingness to share findings and materials (Blumenthal et al., 1997; Campbell et al., 2000), and changed diffusion patterns of new ideas (Evans, 2010).

While these studies have in common that they start from specific institutional arrangements, another stream of research starts from a specific type of research that is singled out by both science policy and science studies. This research is variously termed 'high-risk, high-reward', 'ground-breaking', 'breakthrough', 'innovative', 'frontier', or 'transformative'. The question what conditions are best for such research has been addressed from two directions. Hollingsworth (2008) and Heinze et al. (2007, 2009) identified exceptional research and looked for common conditions under which this research took place. Hollingsworth concluded that "major discoveries tended to occur more frequently in organisational 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." (Hollingsworth, 2008: 321). Heinze et al. found "that creative accomplishments are associated with small group size, organisational contexts with sufficient access to a complementary variety of technical skills, stable research sponsorship, timely access to extramural skills and resources, and facilitating leadership." (Heinze et al., 2009: 610)

Another research tradition starts from funding schemes aimed at supporting exceptional research and asks by what means and to what extent this aim is achieved. Research focuses on the procedures by which projects are selected for funding (Dirk, 1999; Guetzkow et al., 2004; Heinze, 2008; Luukkonen, 2012), or attempts to link properties of research to properties of the funding provided by a particular funding scheme (Grant and Allen, 1999; Lal et al., 2011; Wagner and Alexander, 2013). In the latter studies, grantees and experts in the field were asked to categorise the grantee's research in order to ascertain whether the funding schemes for exceptional research do in fact fund this kind of research.

If we take stock of these perspectives on links between institutional conditions of research and its content we find that the detailed analysis of conditions is not matched by a similarly detailed analysis of research content. Properties of research content at the project level include general aspects of quality (originality, creativity or other 'breakthrough' characteristics as well as validity and reliability of methods) and interdisciplinarity.[1] In many cases, studies have to rely expert assessments for assigning epistemic properties to the research under investigation. The aim of our paper is to contribute to a more detailed analysis of links between epistemic properties of research and institutional conditions for research by ascertaining which properties of a research process create specific funding requirements, and how these requirements are met by project grant schemes.

For this investigation we use data from a commissioned study of the ERC's impact on the European Science system, to which we contributed an analysis of the early impact of the ERC (i.e. the impact of being awarded a grant) on the research and careers of grantees within both schemes.[2] This study required analysing epistemic properties of the funded research, the ways in which the specific funding opportunities provided by the ERC were exploited for the projects, and links between the former and the latter. Investigating such links poses specific methodological challenges, which we discuss when presenting our approach (Section 2). Our data enabled an empirical categorisation of epistemic properties of the investigated projects (Section 3), from which necessary or favourable conditions could be derived and linked to institutional conditions (Section 4). The discussion emphasises the exploratory nature of our research and describes it as starting point for a theoretically and politically important line of research (Section 5). We conclude with a consideration of 'ERC-type' funding schemes as institutional innovation, which in turn has its limits (Section 6).

2. Methodology

2.1. Approach

Our discussion of the state of the art highlighted several conceptual and methodological problems that need to be resolved in investigations of links between epistemic properties and institutional conditions of research. First, there is no systematic operationalisable framework that supports a comparative approach to epistemic properties of research. Most of the properties of fields suggested in the literature cannot be used because they cannot be 'scaled down' to the level of single research processes, and because they defy empirical operationalisation. Few properties at the level of research processes have been suggested so far. Of these, only interdisciplinarity has been operationalised and measured with bibliometric indicators (e.g. Rafols and Meyer, 2007), which limits this operationalization to fields well represented in the Web of Science. The properties used to characterise exceptional research ("major discovery", "creativity", "breakthrough") are extremely vague, and are not operationalised for empirical identification either. This is why the major studies addressing conditions for that research let the scientific communities decide which of its research was exceptional and then studied conditions for this research. The decisions were obtained by direct polls (asking researchers to select exceptional research, Lal et al.), indirect polls (using pre-existing ascriptions by scientific communities, Hollingsworth) or a combination of both (Heinze et al.).

Using expert assessments, while plausible under the circumstances, creates methodological problems for the collection and analysis of data. Since it takes time for a community to form an opinion, exceptional research identified by indirect polls is often research that has been conducted some time ago. This limits the precision of data collection on conditions for that research and their impact. Direct polls can apparently avoid this problem but must operate with democratic votes by experts whose opinions inevitably differ. All studies using polls share the problem that although they obtain legitimate assessments of epistemic properties, they also 'black box' this side of the analysis. By dividing the analysis between experts who establish epistemic properties and

[1] The search for epistemic properties of single research processes or projects must be distinguished from the long tradition in science studies to describe epistemic properties of *fields*. The first of these attempts were based on binary distinctions such as 'hard' versus 'soft' sciences (Storer, 1967; Solla Price, 1970; Biglan, 1973), 'basic' versus 'applied' research (Vollmer, 1972), or 'hierarchical' versus 'concenated' theories (Nagi and Corwin, 1972). Other authors used just one variable such as the degree of 'restrictedness' but allowed it to vary continuously (Whitley, 1977; Rip, 1982). Kuhn's (1962) theory of scientific development led to slightly more differentiated schemes describing a field's 'paradigmatic state' or 'paradigmatic maturity' (Masterman, 1970; Martins, 1972; Lammers, 1974; Beyer, 1978; Böhme et al., 1983). This approach to describing fields has been revived by the distinction between 'mode 1' and 'mode 2' (Gibbons et al., 1994; and between 'old' and 'new' sciences (Bonaccorsi, 2008, 2010). The most differentiated proposal by Whitley (2000 [1984]) uses two dimensions to describe fields (task uncertainty and mutual interdependence). Knorr-Cetina's (1999) comparison of "epistemic cultures" seems to open up the theme to a larger number of dimensions. However, these dimensions are derived *ex post* and *ad hoc* from properties of the two compared fields, and therefore seem difficult to extend to other fields. These distinctions do not seem easily transferable from the field level to the process level, not least because none of the comparative schemes has ever been operationalised, i.e. linked to a protocol for empirical identification of the relevant properties.

[2] See http://erc.europa.eu/sites/default/files/document/file/eurecia_final_synthesis_report.pdf (accessed 14 November 2013).

Table 1
Interviewees.

Panel	ERC starting grantees	Not funded	Non-applicant	ERC advanced grantees	Total
Life sciences	6	2	3	3	
Physical sciences and engineering	6	1		7	
Social sciences and humanities	6	1	1	4	
Total	18	4	4	14	40

sociological analysts who investigate conditions of research, this type of study has difficulties establishing functional links between the two sets of properties, which makes it difficult to go beyond co-occurrence.

This is why we used a different approach in that we derived relevant epistemic properties of research from the data. The fundamental challenge involved in empirically categorising research according to epistemic properties instead of transferring this task to experts is to avoid either a simple reporting of aggregated interviewee opinions or making scientific judgements oneself. Both fallacies would delegate the relevant analysis to non-experts. The interviewed researchers are experts for the content of their research and can describe its epistemic properties. However, they are not necessarily experts for generalising these properties and for building sociologically relevant typologies. Sociological investigators are of course in no positions to scientifically assess the content of the interviewee's research because they have only a layperson's perspective on this research, and would introduce serious distortions if they assessed the content of this research.

Our solution to this dilemma was to solicit and analyse scientific narratives in which interviewees reasoned why their research has certain epistemic properties. These narratives could be triangulated with the grant proposals, which passed an intensive peer review that included interviews of the applicants by the panels deciding on the grant (Luukkonen, 2012). We derived an empirical categorisation of epistemic properties and an empirical categorisation of links between epistemic properties and conditions of funding from comparing the individual cases.

Thus, our general research strategy was to conduct comparative case studies and to increase the likelihood of variation in epistemic properties by

- including a sufficiently large number of cases;
- selecting cases from different fields; and
- including non-grantees as a 'control group'.

We used qualitative interviews for obtaining narratives about the content and epistemic properties of research, and derived an empirical categorisation of epistemic properties from these narratives. Since the interviews also explored the funding requirements and funding of the projects, causal links between epistemic properties and funding requirements could be made on the level of individual cases.

2.2. Case selection

From the discussion in the previous sections follows that cases could not be selected according to their epistemic properties. However, four systematic variations of properties of cases could be used that increased the likelihood of variance in epistemic and funding properties. First, we selected researchers funded under both the starting investigator scheme (18 researchers) and the advanced investigator scheme (14), thereby covering different stages of the development of individual research programmes. Second, we included two 'control groups' for the starting grantee schemes, namely non-funded applicants to the starting investigator scheme who passed the quality threshold (4) and researchers in a comparable career situation who did not apply for ERC funding (4). Third, we selected researchers from different countries according to the case selection strategy of the larger collaborative project (EURECIA). We included researchers from Austria, Switzerland, Germany, France, Italy, the Netherlands and the UK. Finally, we selected researchers from the three major discipline groups in which the ERC funds research, namely life sciences, physical sciences and engineering, and social sciences and humanities. In order to guarantee a minimum homogeneity of cases, we choose one sub-panel from each of the discipline groups and selected interviewees from the same subpanels whenever possible. Table 1 provides an overview of the selected cases.

Our focus on ERC-funded projects creates a selection bias of the investigation. We are not able to systematically investigate research for which the ERC grants are – in the view of either potential applicants or reviewers – unsuitable. Our conclusions concerning institutional conditions are limited by the extensive investigation of only two – similar – funding schemes, and the use of these funding schemes as a lens through which comparisons are made. We will come back to these points in the discussion.

2.3. Data collection

Analysing the relationship between epistemic properties and funding requirements of research required collecting data about the content of research and its links to epistemic properties as well as about funding characteristics of the project. For the first task, we used an interview technique that focuses on soliciting narratives about changes in the content of the interviewee's research and about epistemic properties of the research that are known to influence resource demands and likelihood of success. At the same time, the interview had to be kept open in order to capture properties of the research that were relevant to our question but were not anticipated.

The basic idea underlying this interview strategy is that scientific narratives about the choice of problems, objects, methods, and collaborators are collected. While the content of research cannot be assessed by sociologists, we can reconstruct the logic of the interviewees' description and assessment of epistemic properties of their research as well as the logic of the decision-making by which interviewees responded to conditions of their research.

The interviews with researchers consist of two main parts (see Laudel and Gläser, 2012, appendix for the generic interview guide). In the first part, the research funded by the grant is discussed in the context of the interviewee's research projects, exploring the continuity and all thematic changes and reasons for them. It is prepared by a bibliometric analysis of the interviewee's publications that enables the identification of thematically linked publications. A visualisation of this publication network is used to stimulate the recall and to prompt narratives about the content of research (Gläser and Laudel, 2009; for a similar suggestion see Horlings and Gurney, 2013). The pictures were used for a 'stimulated recall' (Dempsey, 2010) of the interviewee's research biography at the beginning of the interview. Publications of grantees that were listed in the grant proposal were identified in the picture, and the relationship between the ERC project and previous research explored.

The discussion of content requires a scientific preparation by the interviewer at an 'advanced layperson's' level and the negotiation of a level of communication at the beginning of the interview (Laudel and Gläser, 2007, see also Collins and Evans, 2002 on the level of expertise necessary for competent interaction). For this preparation, internet searches, publications at various levels of difficulty (from popular science up to an interviewee's publications) and the ERC grant proposals were used (they were provided by most of the grantees prior to the interviews).

In order to solicit narratives about epistemic properties of the interviewee's research, we raised the following topics in the discussion of research content:

- What are the research questions, empirical objects, methods, and equipment of the interviewee's current research (work on the project submitted to the ERC)?
- How is the interviewee's current research (work on the project submitted to the ERC) linked to his or her previous research? What were reasons for changes?
- How is the current research related to the research interest of the interviewee's community?
- Is the current research in any way risky? Could the research fail, and in what ways could it fail?
- What time and resource requirements result from the research question?

In a second part of the interview, current conditions of research and the factors influencing them were discussed. The separation of the discussions of research content and conditions of research is important because it limits the extent to which interviewees present their own subjective theories about how current funding conditions made them conduct their current research.

We used several lines of questioning in order to address the topics mentioned above from different angles. This included inquiring about other researchers or groups currently working on the same topic like the interviewee and the degree of competition in the field. In the discussion about conditions of funding we also asked what the interviewee would have done if the proposal had failed, i.e. about possible alternative sources of funding.

The interviews lasted 60–120 min. They were recorded and fully transcribed.

2.4. Data analysis

The interviews were analysed using qualitative content analysis (Gläser and Laudel, 2013). Epistemic properties discussed in the interviews were extracted and compared within the interview, with other sources about the interviewee's research and between cases. We present the resulting empirical typologies in the results section. Several of the typologies were not anticipated by the interview guide but resulted from the narratives provided in interviews.

The narratives also demonstrated that the interviewees' opportunities to launch ad hoc rationalisations of their behaviour are limited by what could be called 'scientific narration constraints'. The idea of 'narration constraints' has been developed by Fritz Schütze in his use of narrative interviews (Schütze, 1977; Riemann, 2003). Schütze argued that in their extempore story telling, interviewees feel forced to condense their stories, to provide detail, and to close the structure of their narration (Riemann, 2003: [26]). We observed an analogous phenomenon in interviewees' reasoning about their research and their communities. Interviewees cannot but follow the 'rules of the game' of scientific arguments in their community. They use knowledge currently believed to be true by their community and apply the mode of reasoning that is used by this community in scientific arguments. Responses of interviewees from the same field show characteristic similarities, while arguments from researchers in different fields are systematically different in their forms.

As is common for qualitative studies, we provide quotations from our interviews whenever possible in order to illustrate how we moved from interviews to findings. This turned out extremely difficult due to the necessities of privacy protection. In many cases, the information that is necessary for our argument is also the information that identifies the interviewee. Sadly, we had to learn that this is often the case where epistemic properties of research are concerned, and almost always the case for projects from the social sciences and humanities.

This is also why we can provide only very little information on the interviewees we quote. For each quote, the most relevant information is provided to the extent to which the grantee's identity remains protected. Quotes from interviews conducted in German are our translations. Square brackets indicate changes or omissions that have been introduced to protect the identity of interviewees.

3. Epistemic properties of research projects

The epistemic properties we extracted from our interviews (and corroborated by analysing the grant proposals) include 'relational' and 'local' properties. A first relational property describes the 'planned impact' of the interviewee's research on the research of the community (Section 3.1). This is a forward-looking property because it describes the impact of future results that is envisioned by the interviewees (and, through the peer review of grant proposals, at least by the reviewers). It is therefore different from the notions of creativity or originality, which compare research to what has been done previously. A second relational property is the relationship between the interviewee's research and the current research of other community members (Section 3.2). This question can best be understood as 'sideward-looking' and (slightly) 'backward-looking' because it explores the relationship between current research by the interviewee and current or recent research by others. In addition to these relational epistemic properties, the research also has 'local' epistemic properties that only refer to the research itself (Section 3.3).

3.1. Planned impact of the project on the future research of the scientific community

A first empirical categorization distinguished between 'exceptional' and 'other' research. Instead of trying to operationalise concepts like 'breakthrough' or 'transformative', which are ultimately political, we looked for variation and patterns in our data. We use the term 'exceptional' for denoting research that deviates from common projects in its planned results (Fig. 1). 'Other' research is not intended to have such community-level effects, mainly because it is expected to provide fewer new research opportunities for others.

The envisioned impact of the research on the community was usually described in the project proposal and accepted by the peer review. Not surprisingly, the arguments provided in the interview resembled those in the project proposals. However, they were usually more differentiated and included more extensive arguments.

We could identify two main types of exceptional research, namely planned innovations, which occurred mainly but not exclusively in the sciences, and answers to 'big questions', which we found exclusively in the social sciences and humanities. We define innovations as research findings that affect the research practices of a large number of researchers in one or more fields (i.e. their choices of problems, methods or empirical objects). Half of the grantees we interviewed planned such innovations and promised them in the grant proposal. Planned innovations occurred in all

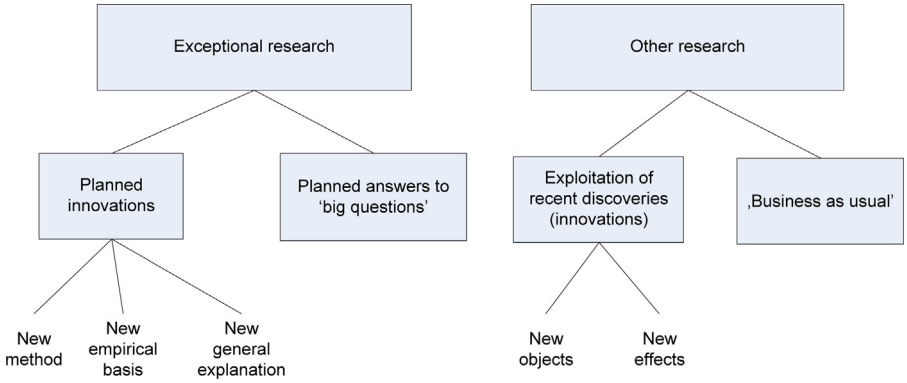

Fig. 1. Empirical categorisation of the ERC research's impact on the knowledge production of the scientific community.

discipline groups. They included the *development of new methods* which, when applicable, will provide new research opportunities to many members of the community.

A second kind of planned innovation, which occurs across all discipline groups, promises to significantly *enhance the empirical basis of a community's research* by providing access to new empirical objects that will be used by many members of the community. An example from the biosciences, which we found on a website of an ERC-funded researcher we did not interview, is the development of a new model organism.

> Due to its high regeneration capacity, small size, transparency and clear morphology, ease of culture, short generation time and amenability to genetic manipulation, M. lignano has great potential as a model organism for stem cell research. Recently the Berezikov group has started developing genomic and genetic tools and resources for this model and at present the group has generated a draft genome assembly, produced de novo transcriptome assembly, discovered several neoblast marker genes and made the first stable transgenic lines in this animal. In this ERC project Dr. Berezikov proposes to study molecular mechanisms underlying rejuvenation in M. lignano and to further advance M. lignano as a model organism through development of missing genetic tools and resources.
> http://www.hubrecht.eu/newsevents/news/2012-07-10.html

The empirical basis of research in the humanities can be enhanced by editions of texts.

> And this corpus was not edited. The first translation of [. . .], was not available; so that's why I decided to work on an edition of these texts for the ERC programme.
> Question: How comes that it never was translated?
> It's a major text, the [. . .], but today if you want to read [. . .] either you go and look at a Latin text, the Latin edition which exists, no problem. Or you look for the modern [translation] of the Latin text. So you have the edition of [. . .] into French or Dutch or German, but you do not have the edition of the very first [translation] of [. . .]. And these texts from the [. . .] century is a translation, chapter by chapter, but each chapter is followed by an explanation of the translator which is very rich; because it gives you the way this person understands the antiquity. It's not only the translation which is important for us but it's a way for us to know how the [. . .] century understands antiquity, understands [the author], understands Christianity.

Similar to the development of new broadly applicable methods, the provision of new empirical objects opens up new research opportunities for a community.

A third type aimed at *general explanations* which, once achieved, will alter the community's understanding of its subject matter. Examples would include the search for a mechanism that influences protein biosynthesis or for general patterns of plant adaptation.

> . . .I am just one of [. . .] this stream of people who at the moment – well, see that we can explain mechanistically. We can – in few cases, always with selected examples and under specific conditions – but we can explain the behaviour of the cell from the dynamic interaction of proteins. We don't need anything else for this. This is extremely difficult, this is technically enormously demanding. It does not work in all cases. Some things are still just too difficult for us – but we can do it. And this is where we should go.
> . . .
> And this is why it is very very important to me, which is why I said: People, this is a topic that has been worked on descriptively for a hundred years. Physiologically been worked on. The [phenomenon]. And this is very good because it is a basis for me. But its mechanistic analysis has been terribly neglected. To attempt to identify the genes that are responsible for building these structures. And this has really been neglected.
> Starting grantee, biosciences

Answers to *big questions* are characteristic for the social sciences and humanities. A typical 'big question' is more general than a common research question of the social sciences and humanities and needs to be answered on an exceptionally broad theoretical, methodological or empirical basis. Researchers would, for example, study a major society-shaping historical process by incorporating all available sources across languages, locations, and types of sources for the relevant period of time. Two grantees had been interested in such big questions for a long time and used their grants to tackle them systematically on a much broader base than was possible before. It is possible or even likely that answers to big questions may have community-level effect similar to innovations. However, due to the highly individualised nature of research in these fields the effects of such research are very difficult to predict. So far, their impact is difficult to ascertain, not least because epistemic practices and the dynamics of fields in the social sciences and humanities have not enjoyed the same attention as the sciences.

It is important to reiterate here that in all cases of planned innovations and planned answers to big questions the actual impact on a community's research cannot be predicted with any certainty because the reception of research results by a community is a diffuse process that is based on autonomous individual decisions by community members.

3.2. Relationship of the project to the community's current research

The interviewees described the relationship between their current research and the current or recent research of other

community members. These descriptions were always provided in terms of the project's position vis-a-vis the community's mainstream. We identified four different ways in which projects deviated from a community's mainstream. Projects that were described by grantees as being different from what most of their colleagues do in one of these aspects were categorised as 'non-mainstream' in one of the following ways.

Contradicting the majority opinion: Several projects contradicted the majority opinion, either by attempting something the community considers impossible or by addressing problems that were considered as irrelevant by the community.

> And I think people just don't do it because the processes are so far apart. In the beginning I said that there are many consecutive steps. And people believe that the second influences the third, the third the fourth; but that a process influence another which is even spatially separate, this is new. And this is where people are relatively sceptical.
>
> Starting grantee, Life Sciences

> The community is not totally convinced that this is a good method. So, I want to change that because I strongly believe that this is not true.
>
> Advanced grantee, Physical Sciences and Engineering

Addressing a community's blind spots: Another version of non-mainstream research addresses a community's 'blind spot' by doing something that does not at all contradict any majority opinion but has not yet been done because nobody else seems to have thought of it. This 'tunnel vision' of scientific communities is a well known phenomenon that has been discussed in the sociology of science since Kuhn (1962) introduced the notion of a paradigm and its orienting effects.

> And the problem with the study of [X's] history is that all the narrative sources we have ... they all were written down 200 years later. So we don't have anything contemporary for this period which means a lot of people have said 'we cannot study this early period because we don't have anything contemporary'. But the [texts] are contemporary. So in a way, it's almost natural to understand what's happened [in this early period]; the [texts] is such a fantastic source. So if you're interested in looking at the [texts] it's a very easy topic to get to. It's such a big blind spot in our knowledge and our understanding of [X's] history.
>
> Starting grantee, Social Sciences and Humanities

Applying non-mainstream approaches or methods to mainstream problems: A third non-mainstream relationship occurs when projects apply non-mainstream approaches or methods to mainstream problems.

> I think people at the whole are friendly to that. I do get some criticisms, particularly from the historical linguists saying, yes, but don't underestimate our field. Sometimes I get a bit of a feeling that people feel that I am trying to move too fast by not following all the steps that they would have taken. The basic methodology in historical linguistics was a success story, was set up by Grimm and Hermann Paul and other great 19th century historical linguists. Basically, it hasn't changed since then. In some sense, the field has been a bit a victim of its own success. It was a very important field and the discovery of the European and all these other large families was a big success in the 19th century. But then the field got frozen a bit. I think it is time for new techniques to come in.
>
> Advanced grantee, Social Sciences and Humanities

Linking otherwise separate communities: Finally, non-mainstream research includes attempts to link communities that have no previous epistemic connections. These are cases of 'emergent interdisciplinarity', which sometimes include cognitive mobility.[3]

> Normally these are two separate fields. They have separate meetings, separate conferences, they are separate communities... But these are two very big fields which are far apart. Since we deal with everything between these two fields, we naturally have a big area to cover.
>
> Starting grantee, Life Sciences

The last two versions can be thought of as producing new 'cognitive complementarities', a concept used by Bonaccorsi (2008: 306, 2010: 359–367) to address interactions between disciplines. In both versions, knowledge or tools that were unrelated before become complementarities because they can be related to one another in a research process. Creating these links is a specific field-level effect of the research.

The four versions of non-mainstream research are not mutually exclusive. The link between two communities may be a blind spot for both, the application of non-mainstream methods to mainstream problems may contradict the majority opinion, and so on. The most extreme example in our cases is a project from the social sciences and humanities which 'manages' to meet all four definitions of a non-mainstream project. The interviewee described her topic "as absolutely not fashionable" because she reopens an old discussion (contradicting majority opinion). She stated that she has a "completely different approach" that does not fit the traditions of the field and contradicts the classical definitions (non-mainstream approach); that she is looking "at things that are not investigated [in that area]" (blind spot); and that she investigates an object which is the subject matter of several otherwise separate communities (linking communities).

3.3. 'Local' properties of the research

In addition to its epistemic links to the field, the research of our interviewees also has 'local' epistemic properties, i.e. properties that characterise the individual research process. We explored such local properties in previous research (Gläser et al., 2010) but did not have enough material for developing an exhaustive comparative categorisation that could have been used as a theoretical categorisation *ex ante*. We could, however, use these prior observations and the literature on epistemic properties of fields as heuristic input.

In our empirical investigation we found that the complexity of objects, their dynamics, and pre-existing knowledge about them created six 'local' epistemic properties of projects in our sample, which we will now discuss in more detail. A first epistemic property can be described as the *number of the properties of an empirical object its context that must be simultaneously controlled* in an empirical investigation. This property is different from the research object's complexity because it does not refer to the multitude and diversity of an object's and its context's properties but to the number of these properties that must be controlled, i.e. understood and influenced or measured, in the research process.[4] The specific methodological challenges emerging from a high number of properties needing

[3] We don't claim that the ERC has solved the enduring problem of assessing interdisciplinary research because we do not have sufficient data to answer this question. However, the projects in our sample included some with interesting forms of interdisciplinarity.

[4] Bonaccorsi (2008: 290–293) characterises what he terms "new sciences" as dealing with complex objects. This field-level property does not straightforwardly translate into the complexity of the object of a single research process because the number of variables and conditions that needs to be controlled depends on the specific research question, and can therefore vary considerably between research processes in both Bonaccorsi's "old" and "new" sciences.

control vary depending on the degree to which methods are *technologized* (a second epistemic property). We found four projects that were based on controlling a large number of the object's properties with highly technologized methods, all of them in physical sciences. In order to illustrate this property, we quote a description of the first manufacture of Bose-Einstein condensates given by Nobel Laureate Wolfgang Ketterle, which also indicates the dynamics of control: What once was difficult to achieve in simultaneous control is today a standard experiment.

> Nobody had done absorption imaging—to take shadow pictures of atoms. There were early precursors of magnetic traps in the 1980s, but between 1993 and 1995, we developed room-temperature magnetic traps with high-current power supplies, and all that had to be engineered. Everything had to be done at ultrahigh vacuum, which was not the case with previous experiments. It sounds very mundane because those techniques are now standard in many atomic physics labs around the world. But after Bose-Einstein condensation was first observed, it took other groups two years to repeat it. This was the challenge they had to overcome. They had to learn all these techniques, and then get everything to work at once. (Ketterle, 2004)

The research objects of projects from the life sciences were of course not less complex. However, the control that was necessary in the experiment included fewer properties of these objects, and was less specific to the research question of the projects.

If the number of properties to be controlled is large but not extremely high, the degree to which methods are technologized is low, and the *decomposability of control* (a third epistemic property) is low, the control can be established by an individual researcher 'keeping it all in mind", which creates the individual long-term projects characteristic for many of the humanities and some of the social sciences.

A fourth epistemic property is the long '*Eigentime*' of a research process, which is defined by material properties of empirical objects and research technologies, for example growth and reproduction cycles of biological objects. In our analysis, we found one example for an unusually long '*Eigentime*', namely a project that included the observation of a biological process that takes years and required an observation time of at least three years.

Two more epistemic properties of research refer to the uncertainties inherent to a project. S*trategic uncertainty* is the uncertainty concerning the existence of an outcome. Effects might either not exist at all or not be observable with the current experimental setting. Attempts to generalise effects might fail because what has been found is idiosyncratic. This kind of strategic uncertainty we found in seven projects, all of them from the natural sciences.[5]

> . . . people said, this is really very risky, what are you doing if it [the mechanism] doesn't exist? If it doesn't exist then the project is dead, of course. That makes it very risky. And that's how the reviewers have seen it as well.
>
> Starting grantee, Life Sciences

There were also cases of high strategic uncertainty where it was already clear at the time of the interview (about three years into the project) that the hoped-for effects did not exist and the most ambitious aims of the projects could not be achieved.

> Answer: [I am] not getting the high resolution as I'd like it to and that's something that became apparent even after the grant was funded.
> Question: It's not meeting the expectations you had?
> Answer: Yes, that there's some critical problems that may disqualify the technique.
>
> Starting Grantee, Physical Sciences and Engineering

Technical uncertainty refers to the lack of knowledge about the way in which a certain goal can be achieved. The building of experiments might include a lot of trial-and-error manipulation of equipment before the intended effects can be achieved. Stages of experiments might fail, either because the outcome is partly random or because the experimental conditions cannot be fully controlled. The equivalent in the social sciences and humanities is a situation in which data that are necessary for answering the question cannot be found in time. We identified a significant technical uncertainty in nine projects, one of them from the social sciences and humanities, where it referred to the possibility that the sources would not yield enough information to answer the question. But even in this particular case the interviewee's understanding of failure was to produce different and maybe worse results than intended. None of the projects in the social sciences and humanities could fail completely, as is the case with the following project:

> And nobody in the world tells you how good the vacuum is, and most of all, how one can measure that. And this is a knock-out criterion. This we will investigate first in the system. If the vacuum isn't good in the place where the atoms must be, then the project fails technologically. Then one cannot even investigate the interaction.
>
> Advanced grantee, Physical Sciences and Engineering

Not all of the investigated projects were strategically or technically uncertain. The following conversation clearly demonstrates that the interviewee who planned an innovation does not think of her project as risky.

> Question: [.] to what extent can you fail with your ERC project?
> Answer: Okay. Well I hope I will not, but the only thing that I could see is that it would take too much time to do the first [editions]. For some reason we would work slowly because there are some difficulties that I did not see at the very beginning so we have to go slowly. Then at the end of five years we're not able to show that we have done the whole [. . .] edition.
>
> Starting Grantee, Social Sciences and Humanities

4. Links between epistemic properties and institutional conditions

4.1. Epistemic properties, necessary or favourable conditions for research and institutional conditions

The link between the epistemic properties of research projects established in the previous section and institutional conditions is quite complex and requires an additional intermediary step. We will first ask what conditions are necessary or would be favourable for projects with specific epistemic properties, and then link them to institutional conditions (Fig. 2).

If a research question requires controlling many properties of an object and its context and methods are highly technologized, research equipment controlling the various properties must be combined in a single experimental setting. These experiments require *complex task-specific equipment*.[6] The need for complex

[5] Our use of the concepts 'strategic uncertainty' and 'technical uncertainty' differs from Whitley's (2000), who introduced the terms in his comparative analysis of scientific fields. Whitley applied the term 'technical uncertainty' to all epistemic uncertainties of a field's research and used 'strategic uncertainty' to describe the uncertainty of gaining reputation. In our description of research projects it is useful to differentiate between uncertainty concerning the possibility of a specific outcome (the existence of an effect) and uncertainty concerning the way in which an outcome can be achieved.

[6] Complex task-specific equipment is clearly different from Bonaccorsi's (2008: 306–307, 2010: 366) observation of "medium-size, general purpose facilities" that

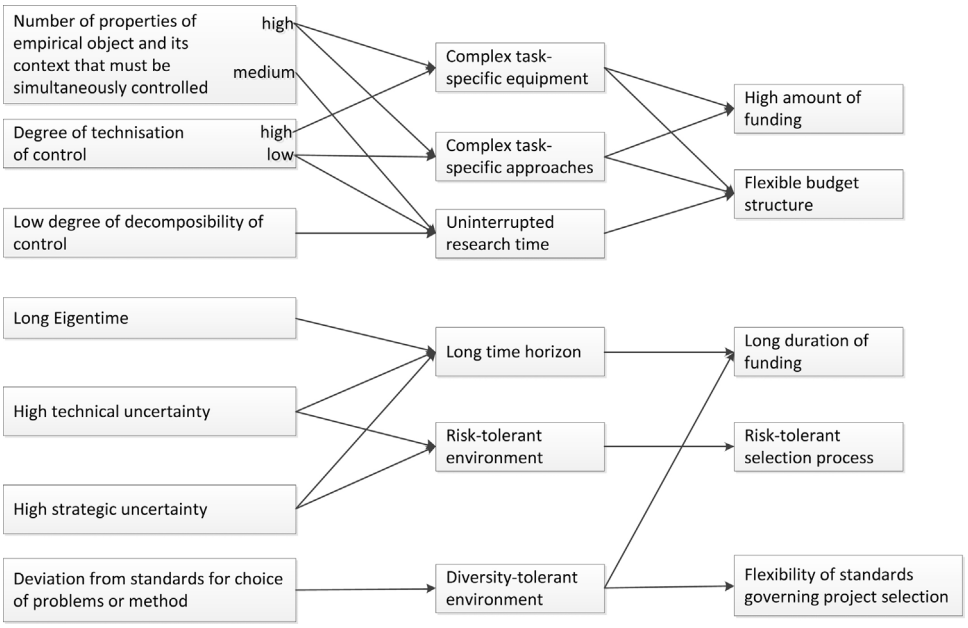

Fig. 2. Links between epistemic properties of research, necessary and favourable conditions for research and institutional conditions.

task-specific equipment for specific experiments occurred in the four projects in which a high number of properties had to be controlled by highly technologized methods. In each case, the generation or observation of empirical objects required either one large instrument that was specifically built for the project or the integration of several instruments into a task-specific experimental system. All projects in our sample relying on complex task-specific equipment belonged to the physical sciences. In contrast, the equipment for life science projects was more generic and more modular, and could thus be accumulated by standard grants and utilised across projects.

In projects that need to control many properties but do not rely on technologized methods, the multitude of knowledge and intellectual approaches dealing with these properties must be applied by the researchers themselves. *Complex task-specific approaches* are the social sciences' and humanities' equivalent to the complex task-specific equipment in the natural sciences. The complex task-specific approaches took the form of the integration of different approaches in an 'interdisciplinary' group, in which the joint work on a common subject matter requires the co-presence of researchers mastering these approaches during the whole time of the project. 'Interdisciplinary' is meant here in the weakest possible sense and may include the mastery of different languages or the familiarity with different types of sources.

> [The second language] is really much more integrated in the sense that before I was using it passively. And now I really have two scholars, hopefully the other one will start in [the first language], but the [second language] is someone who's actively working in it. So I actually get new material and am more aware of things that are developing in that field.
> The other thing, the other interdisciplinary bit to it, which I can see is provided by me and by one of the PhDs, is to really have the historical dimension there.
>
> Starting grantee, Social Sciences and Humanities

The holistic nature of approaches in the social sciences and humanities are a response to the low degree of decomposability of the control of properties, which need to be taken into account simultaneously. This is why collaborative designs that define sequential, sub-task specific contributions of collaborators who may be separated in space are rarely applicable.

> Question: Okay. Could you have done it more successively – that you start with the [first part] and . . .
> Answer: Well. It would have been hard to imagine in the sense that probably the types of moneys that I would have been able to get would be much more tied to specific questions than to a single question like I have now. I would not have been able to answer a single question on these four levels this way.
>
> Advanced grantee, Social Sciences and Humanities

The holistic nature of research processes and the low decomposability of control of properties created a specific need for *uninterrupted research time*. All knowledge about the research object must be constantly kept and actualised in the mind of the researcher, which makes it extremely difficult to enter the necessary 'research mode'. In more technical terms, the properties of the human mind as the major research tool create the necessity to constantly 'run' – engage in research – without interruption by other tasks, because each interruption requires a major recalibration.

A *long time horizon* can be a necessary or favourable condition for research for several reasons. The link is obvious for the long *Eigentime* of the research process. A long time horizon can also be necessary because of a project's technical uncertainty. Technical uncertainty means that 'making experiments work' can take two to three years. Thereafter, researchers need to conduct the experiments and publish from it. Publishing is essential for subsequent grant applications. Since grant funding is essential for research in many fields and countries, this whole sequence would need to occur prior to the end of each grant. This is particularly important for young investigators who might not hold too many grants simultaneously. Several grantees emphasised that due to their projects' technical uncertainties they would not have started them if they hadn't had a five year time horizon.

> Uh, it takes two. . . minimum of two years to set it up, probably minimum of another year to get the data, understand the data,

are needed in what he termed the "new sciences". Apart from the difference already mentioned – Bonaccorsi describes field-level rather than process-level properties – the facilities described by him are generic, i.e. they can be used across a variety of research processes.

and write the first paper. So it would have been a three years black hole, which would have been *difficult*.

Starting Grantee, Physical Sciences and Engineering

Finally, strategic uncertainty may require a long time horizon because the search for the effect or phenomenon may take a long time. It might be difficult for researchers to prove a negative, i.e. to know whether the effect is not there or whether it cannot be found due to deficiencies in the experimental setup.

The strategic and technical uncertainties inherent to some of the projects also made them inherently risky, which means that they required an *environment that tolerates these risks*. In the same sense, the investigated projects that deviated from the mainstream of their fields require *environments that tolerate diversity* instead of suppressing such deviations.

These necessary or favourable conditions for research can now be linked to institutional conditions and thus to grant funding. This leads to a simplification because institutional and institutionally defined conditions can be limited here to the question of discretion over specified resources for specified times, and the allocation decisions concerning resources.[7]

Both complex task specific equipment and complex task-specific approaches require above-average amounts of funding and flexible budget structures. Experimental systems may include custom-build devices. Prices of single pieces of equipment or required combinations may easily exceed one million Euros. Complex task-specific approaches are likely to require the co-presence of many specialists in a research group. This is unusual in many fields of the social sciences and humanities, whose research is characterised by projects that are designed and conducted by one researcher. In these fields, groups of three or more people (as the one consisting of three language specialists and a historian described in the previous section) are unusual and generate above-average funding requirements and unusual budget structures.

Long time horizons and the need for a diversity-tolerant environment may be translated in the necessity of a long duration of funding. The link is obvious for the long time horizon. A diversity-tolerant environment is supported if the new epistemic arrangements of a project are given enough time to be accepted, which is also supported by a longer duration of funding.

Two of the necessary or favourable conditions for research address the selection processes for resources (including, but not limited to, those of project grants). For a risk-tolerant and diversity-tolerant environment to work, these properties must be translated in selection processes. The allocation processes of resources to research must support risky projects, and must support projects that are at odds with dominant expectations of a field. This is why risk-tolerant selection processes and the flexibility of standards governing project selection (see Whitley, 2014 for the latter) are important institutional conditions for projects which are technically or strategically uncertain and deviate from standards for choice of problems and methods.

4.2. Institutional conditions provided by ERC project grants and alternatives

The institutional conditions described in the previous section are obviously at odds with the implicit standards of grant funding. Many funding programmes are based on a standard pattern that includes a maximum of three years of funding, a maximum amount of funding, and an expectation of the proportion of that budget that is spent on equipment. Often there are also expectations concerning the size and composition of funded research groups. These standard patterns, which also inform the peer review of projects, do not fit the necessary or favourable conditions research projects with the epistemic properties described in the previous sections.

Recurrent funding in research organisations is subject to similar constraints. In universities it is often limited to small, grant-like sums whose sole purpose is to give the recipient the opportunity to prepare an application for an external grant. In most other cases, it is likely to be subject to the same constraints as external project grants, whose format has by now become a ubiquitous blueprint for research projects.

The new political drive to fund 'excellent' or 'breakthrough' research has led to institutional innovations in project funding that consciously deviate from the standard pattern. Based on the assumption that 'breakthrough' research has uncommon funding requirements, funding schemes that create the institutional conditions described in the previous section have been established. The ERC is a case in point. Although not the first of these funding schemes (Heinze, 2008), it is a prime example of the principles applied to funding 'breakthrough' research. In the following, we briefly describe how the selection process and the conditions provided by grants meet the institutional conditions. This description is given from the perspective of grantees (see Luukkonen, 2012 for an independent investigation of the ERC's selection process). We also use the grantee's perspective on alternative funding opportunities for their projects and the fate of the control group research for the description of institutional conditions provided by grant funding.

ERC funding deviates from the standard pattern in the amount of funding offered (from two up to 3.5 million Euros), in the flexibility of budget structures (no standard exists), in the duration of funding (five years), and in the explicit invitation to submit risky and unconventional projects. When discussing the funding requirements of their projects, the interviewed grantees did so by comparing ERC funding to alternative funding opportunities in their countries.

4.2.1. High amount and flexible use of funding

Complex task specific equipment may require an investment beyond what is available to a researcher through 'normal' channels, i.e. from their research organisations or through grant funding. Whether there are alternatives available to starting or advanced grantees depends on the grantee's national funding landscape. For example, interviews suggest that it is possible to obtain large grants for equipment from the UK's Engineering and Physical Sciences Research Council, while the following quote indicates that the same thing seems quite impossible in Germany:

> We are talking about a million Euros. This is not easy. A [device] for 100,000 Euro you can still get. But a [device] that costs a million you just don't get as a German. There is just no opportunity for a German researcher to apply alone with the DFG for a one device that costs a million Euro. You don't get it. I played this card with the ERC and said 'if you want to promote this kind of research in Europe then you must give me the money because otherwise it is not going to happen. This is how it is. I didn't have [the device] if the ERC grant had not come.
>
> Starting grantee, Physical Sciences and Engineering, Germany

Similarly, receiving as an individual researcher funding for a large group on which a complex task-specific approach can be based seems quite difficult under these circumstances and make the ERC the only or at least the most attractive source of funding.

> And this was actually the reason why I submitted this [ERC] project. I thought that all I need to understand for appropriately investigating this topic requires including several people who work on similar things rather than working alone.
>
> Starting grantee, Social Sciences and Humanities

[7] Institutional conditions for research are of course more complex and include, for example, informal generalised expectations concerning 'good' and 'useful' research as well as legal frameworks that govern ethical as well as environmental aspects of research methods.

One grantee reported 'shelving' an idea because he did not see an opportunity to realise it until the ERC provided him with the opportunity to have a sufficiently large group.

4.2.2. Long duration of funding

Although the ERC grants are not the only ones that fund research for five years, this duration of funding is rare enough to constitute an exception, particularly in connection with the other exceptions. Most project grants have a term of two to three years. In this context, the ERC grants were considered as long-term funding by grantees even though five years are a long time horizon only in relative terms. A long duration of funding was e.g. necessary for humanities researchers, who could 'buy' the necessary long uninterrupted research time with their ERC grant:

> I try to make it brief. It is the time. First of all you need time, if you have additional money for travel, the better. This is clear. But my experience was . . . There are offers, for example in [. . .] there are funding schemes for mid-level academics that offer you 50,000 Euros for two to three years. But I have never applied for money in my time at [. . .] because I had not needed it because I needed time. I would not have been able to buy time. I could not have used it to fund my position. And the interesting thing about [other funding programme] and the ERC is that I can fund my own position, can give myself the time.
>
> Starting grantee, Social Sciences and Humanities

4.2.3. Risk-tolerant selection process and flexibility of standards

Although the ERC invited such projects from the beginning, they should not have been funded for the reasons mentioned above. To our (and to some of our grantees') surprise, the ERC did not only manage to invite the submission of unconventional projects, at least some of its panels also accepted them for funding.

> They wouldn't have done it. I don't believe they would have funded it . . . I probably would have tried it . . . but I don't think the [national funding agency] would have funded it. [. . .] the ERC has from the beginning . . .always said "high risk, high gain, new avenues of research, new horizons, frontier research". I had been very very sceptical whether they really do this . . . They did it. I would not have believed it. This is the beauty of it – it is unlikely that I would have gotten it and definitively would not have started it with a proposal to [national funding agency].
>
> Life sciences, starting grantee

While this grantee did not try to apply with his national funding council because he was convinced that the project was too risky to be funded, other grantees tried and failed:

> 'For example we applied for a [Research council 1] and we applied for [Research Council 2] grant. [The project] . . . was very similar. And they . . . valued maximum but they didn't fund it. Because there were many alpha pluses and among them they chose the ones with the non-risk. Because all of the policies [Research Councils 1 and 2] use, they want to fund projects with low risk.'
>
> Postdoc working with an advanced grantee

Some grantees (four from our sample) did only half-believe the ERC's invitation to submit risky projects. Four of them split their project proposal in a non-risky 'bread and butter' part and a risky part.

> If you read my project proposal, it has two parts . . . The first is actually a risky project, where people said this really is very risky. . . And this is how the reviewers saw it, too. While with the second, albeit it is also something where you don't know what the results will be, it is relatively likely that at least some [. . .] sites will be found. This is where they said 'Ok, we don't know what will happen but at least something will come out. . .'.
>
> Starting grantee, Life Sciences

In order to triangulate interviewees' statements about necessary conditions for project success, we inquired about alternative sources of funding that would have made the research possible. Interviewees were asked how their project could have alternatively been funded, and what they would have done if the ERC had rejected their proposal. Although both questions have their prob-

Table 2
Alternative funding opportunities for the ERC project as perceived by grantees and non-funded applicants from the life sciences (LS), physical sciences and engineering (PSE) and social sciences and humanities (SSH) panels (numbers of cases in brackets, cases where fully equivalent grants were assumed to exist are set in italics).

Country	Starting grantees			Advanced grantees		
	LS	PSE	SSH	LS	PSE	SSH
NL	Combination of several grants (2)	*Vici grant*[a] (1) Combination of several grants (1)	None (2)	Combination of several grants (1)	Combination of several grants (1)	None (1)
D[b]	None for the risky part and *DFG* for the other part (1)	None (1)	Emmy Noether grant (1)	*Reinhart Kosselek grant* fort the risky part and *DFG* for the other parts	Combination of several grants (3)	None (1)
UK[c]	None for the risky part and *BBSRC* for the other part (1)	EPSRC (1) *EPSRC* for the risky part and none for the other parts (1)	None (1)			None (1)
CH[d]	None (1)	None (1)		None (1)	None (1)	
IT[e]	None (1)				None (1)	
F	Combination of several grants (1)		None (1)			
AT	Combination of several grants (1)		START grant[f] (1)			

[a] Vici grants are awarded to researchers between eight and 15 years after their PhD. The maximum amount is 1.5 million Euros, the duration of funding is five years.

[b] In Germany, the DFG (*Deutsche Forschungsgemeinschaft*) is the most important public funding agency for university research with many different funding schemes. These include the *Emmy Noether* funding programme, which enables young researchers (two to four years after their PhD) to build their own research groups. Funding is for five years with no formal limit to the amount. The *Reinhart Kosselek* funding programme funds researchers with outstanding scientific achievements (usually university professors) for five years, the maximum amount is 1.25 million Euros. About two researchers are funded per year.

[c] The BBSRC is the UK's Biotechnology and Biological Sciences Research Council. The EPSRC is the UK's Engineering and Physical Sciences Research Council.

[d] All Swiss grantees stated that they would have reduced their project and tried to receive funding from the Swiss National Funds for the reduced project.

[e] In two Italian cases the information in the interviews was not sufficient for categorising the cases.

[f] START grants are awarded to researchers two to ten years after their PhD. The maximum amount is 1.2 million Euros, the duration is six years. Up to eight researchers are funded each year.

lems – the answer to the first one depends on interviewees' perceptions of their funding environment, the second is hypothetical – they can be used to triangulate information about the conditions for success of the projects (Table 2).

There were only three cases in which interviewees assumed that there is a grant equivalent to the ERC grant. In all other cases, alternative funding was deemed impossible, possible only for a changed project, or possible only with the combination of several grants from different sources.

These perceptions are clearly discipline-specific and country-specific. The interviewees from the natural sciences (Life Sciences and Physical Sciences and Engineering panels) often thought it possible to achieve the ERC grants' level of funding by combining several national grants. Naturally, this alternative bears the additional risk of not being awarded all the grants as necessary. It is also likely to stretch the research across more than five years due to additional application phases and synchronisation problems. However, due to the modularity of their research problems this alternative seemed possible to some interviewees. The exceptions that show even through the hypothetical answers are interviewees who did not assume their risky projects or project parts would be funded by other agencies, and interviewees who assumed that there is no funding for their projects because costs for equipment were indivisible and exceeded the limits of all funding schemes known to them.

The case of the social sciences and humanities is even more pronounced. Most interviewees from this discipline group did not believe that another funding source would fund their project. An ERC grant provides the opportunity to build a research group, which is still unusual for the social sciences and humanities and thus not commonly provided for by national grant schemes.

In addition to these perceptions of grantees, we explored responses to the rejection of ERC grant proposals of the four researchers who passed the ERC's quality threshold but were not funded. Of these four researchers, one managed to start his project without ERC funding by obtaining two thirds of the funding (the expensive equipment and some of the positions) from the recurrent funding of his research institute and topping this up with a standard grant from his funding agency. A second researcher obtained even more funding than he applied for with the ERC from an external funding source that rewarded all applicants who passed the quality threshold but could not be funded due to the limited budget of the ERC. The third researcher lost interest in the topic of his ERC project and abandoned it altogether. Finally, the fourth researcher obtained funding from national sources, which enabled work on the ERC topic with less than half the personnel and about half the equipment at a much slower pace.

5. Discussion

The aim of our project was to identify links between epistemic properties of research processes and institutional conditions that govern the allocation of funding. We conducted a comparative in-depth analysis of projects, from which we derived epistemic properties of projects that both cover the specificity of research and support comparisons across fields from the natural sciences, life sciences, and social sciences and humanities. Although several of the properties we identified bear some resemblance to those attributed to fields in the existing literature, the adaptation of these suggestions to the description of projects is not trivial. Most of the process-level properties do not even make sense at the field level if one would consider them as averages. Doing so would also obscure the enormous variation between research processes of a field, which is problematic because fields are not influenced by governance connecting to their average properties but by governance connecting to specific properties of individual research processes, from which field-level effects emerge.

The link between epistemic properties and institutional conditions can be made through an intermediate step that links epistemic properties to necessary or favourable conditions for research, and subsequently asks how these conditions can be produced by institutional conditions. The latter step included a significant reduction of complexity, which is partly due to our focus on grant funding. The picture is likely to become more complex if all institutional conditions are taken into account, particularly if conditions provided by the organisation are included.

Our research is explorative and needs to be extended due to several limitations of the methodology. The crucial limitation concerns the number of cases. Given this restriction, we cannot assume our framework to be exhaustive on the three levels we introduced, namely epistemic conditions, necessary or favourable conditions, and institutional conditions. The framework is likely to be extended and corrected on the basis of more cases from different fields, more cases of projects conducted under a wider variety of institutional conditions, and more comparisons between funded and non-funded applicants to the same funding schemes.[8]

A further limitation, which is much more difficult to overcome, concerns the selection process of grant proposals. This is of course an important institutional condition that addresses two crucial epistemic properties, namely the uncertainties involved in projects and their deviation from community expectations. Ideally, an investigation would encompass a project's selection process, conduct and outcomes. However, we experienced the commonly known reluctance of applicants and funding agencies to fully share the information about the selection process. It is difficult to see how this problem can be overcome.

We do claim, however, that the levels we introduced are theoretically and politically relevant because they enable a detailed analysis of the 'nuts and bolts' that link researchers' practices of producing new knowledge to politicians' and managers' practices of shaping conditions for research. Governance changes research content at the level of research processes, which requires the analysis of governance to follow through.

6. Conclusions

While competitive grant funding may improve resource allocation and thus the overall performance of a science system, its standardisation of project formats prevents some research from being funded. This research includes what we characterised as planned innovations – research that is intended to influence the researcher's community. Much of this research has epistemic properties that demand conditions for research which cannot be met by standardised grant funding. Nor can they be met by recurrent funding any more because this funding has been shifted to project funding. In their analysis of conditions for creative research, Heinze et al. (2009: 610) state that "a potential institutional threat to creative science is the increase in competitive research council funding at the expense of flexible institutional sponsorship."

The crucial point of weakness of the transition from recurrent to competitive grant funding appears to be the low institutional diversity of the competitive funding schemes. In this situation, 'ERC-type' funding schemes – funding schemes that offer large amounts of resources that can be flexibly used for a relatively long time (five years and more) constitute an institutional innovation that increases the diversity of conditions for research. The ERC is

[8] For example, there is also high risk and otherwise unconventional research that can be conducted with small grants (Grant and Allen, 1999; Wagner and Alexander, 2013).

not the only funding scheme of that kind, but it is a highly visible one, which has sparked some copies.

While the limited scope of our investigation does not support a comprehensive account of conditions for 'breakthrough' research, our translation of this political term into 'planned innovations' (predominantly in the sciences) and 'answers to big questions' (predominantly in the social sciences and humanities) enables a detailed account of conditions for some research that can be assumed to fall into the 'breakthrough' category. This research has specific epistemic properties, which translate into necessary or favourable conditions that are met by ERC-type funding schemes but not by others (see the table in Appendix A for a synopsis).

ERC funding shares a feature with most institutional innovations of the last three decades. It is flexible in some dimensions but a 'one size fits all' – institution in others. It is build after a blueprint derived from the biosciences or, more general, smallscale collaborative experimental science. It thereby adds a new standard of funding that is deemed applicable to all disciplines. The effects of this new standard are yet unclear. For example, it seems to promote a type of research that is currently uncommon in the social sciences and humanities. It remains to be seen to what extent this will change research practices in these disciplines, and what the effects on knowledge production will be. It is not impossible that high profile funding schemes for exceptional research initiate at least a partial transition of the social sciences and humanities to research by interdisciplinary groups.

With regard to theory, we would like to stress that connections between epistemic properties of research and institutional conditions of funding can be made, which provides an important link between the sociology of science and science policy studies. It also provides a way for both fields to move towards a comparative framework for the empirical comparative analysis of research in different disciplines and the impact of institutional conditions on the content of this research. We think that we were able to use a common framework for research from the humanities, natural sciences and biosciences, and to address the theoretically interesting and politically important epistemic differences between them.

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Appendix A. Epistemic properties and funding requirements of the investigated ERC projects (three projects could not be fully categorised)

	Life Sciences									Physical Sciences											Social Sciences and Humanities								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9
Relational epistemic properties																													
Impact on community[a]	O	O	B	O	E	E	E	E	O	O	O	M	M	M	O	E	B	O	M	O	O	Q	Q	B	O	O	O	E	M, B
Relationship to community[b]					C,L	B	M	M								M,L	B,M		C,B			B,M			All				B,M
Local epistemic properties																													
Large number of properties											■					■						■	■		■				■
Methods technologized	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Low decomposability of control																					■	■	■	■	■	■	■	■	
Long 'Eigentime'																						■							■
High strategic uncertainty					■		■					■	■	■		■	■		■										■
High technical uncertainty	■					■		■	■			■	■	■											■				
Necessary or favourable conditions																													
Complex task-specific equipment											■					■													
Complex task-specific approaches																						■	■		■				■
Uninterrupted research time																								■					
Long time horizon			■									■	■	■			■					■		■					■
Risk-tolerant environment	■				■	■	■	■	■			■	■	■		■	■		■						■				■
Diversity-tolerant environment					■	■	■	■								■	■		■			■			■				■
Institutional conditions																													
Amount and flexibility of funding											■					■	■					■	■	■	■			■	■
Long duration of funding	■		■			■		■	■			■	■	■			■							■				■	■
Tolerant selection process	■		■		■	■	■	■	■		■	■	■			■	■		■			■	■	■	■			■	■

[a] M = new methods, B = new empirical basis, E = new general explanation, Q = addressing 'big questions', O = 'other' research.

[b] C = contradicting majority opinion, B = addressing a 'blind spot', M = applying non-mainstream methods to mainstream problems, L = linking communities.

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