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Funding

The art of getting funded: how scientists adapt to their funding conditions

Grit Laudel

Shrinking university budgets make university researchers more and more dependent on external funds. As a response, they develop specific strategies for selecting external funds and for adapting their research. In a comparative interview-based study of experimental physicists working at Australian and German universities, connections between their funding conditions and adaptation strategies were analysed. Strategies differ between scientists in the two countries because of different funding conditions; and they differ between top scientists and others. The adaptation affects the content of research, for instance, its quality and innovativeness. The findings can be generalised to resource-intensive fields that underwent a shift from recurrent to external funding.

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This article has benefited from discussions with Jochen Gläser and comments by Renate Mayntz, Uwe Schimank, Peter Weingart, and several unknown reviewers. As one important result of these discussions, the author hopes to have strengthened her arguments sufficiently to convince readers that the outlined causal relationships do indeed exist, and are not merely her rationalisation of scientists' common complaints.

THE PREVIOUS RAPID GROWTH of the science system, the rising costs of conducting science and the financial pressures on government budgets have impacted on the funding of science. Many countries have undergone a change in the funding of their university research, with one of the main trends being a shift from recurrent funding (resources provided yearly by the university) to external funding of projects.

Shrinking university budgets cause researchers to rely increasingly on this external funding of research projects, placing them in a resource environment that is characterised by scarcity, competition, and continuous evaluation. This is intended insofar as the increasing competition is assumed to lead to a higher quality of research, and enables the funders to induce innovations in science such as new interdisciplinary collaborations.

However, another possible consequence of these changes is that scientists adapt to the new conditions by producing different knowledge. In a context where science policy intends to gain high-quality research without changing its direction, these thematic adaptations must be regarded as unintended side-effects. For example, the knowledge production could be affected in the basic vs applied, disciplinary vs interdisciplinary, or theoretical vs methodological vs empirical dimensions, or in the way results are communicated, for instance, with regard to scientists' publication practices.

The problem of changing universities and, more generally, funding conditions, have previously been examined from three different perspectives. A first line of research investigated the links between funding and the growth of scientific fields. A workshop by the US National Science Foundation on Funding

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and Knowledge Growth attempted to explore the relationships between funding and knowledge production of fields.

However, the studies presented at this workshop remained on a macroscopic level. Knowledge growth was treated quantitatively rather than in terms of knowledge content, and causal mechanisms that mediate between the extent of funding and the growth of knowledge were not explored. Thus, the workshop led to "challenges for science policy studies" rather than answers to the questions it posed (Cozzens, 1986; see also the critical comments of Noll *et al*, 1986).

Secondly, the problem of changes in knowledge production surfaced in studies of the fairness and reliability of peer-reviewed grant distribution. Chubin and Hackett (1990: 60–65) reported that between a third and a half of the scientists whose proposals were initially denied stopped a particular line of research, and that 60% of the respondents to one survey believe that reviewers are reluctant to support unorthodox or high-risk research.

The risk-averse perception of peer-reviewed grant distribution was confirmed for Germany's Deutsche Forschungsgemeinschaft, the most important funding agency for university research (Neidhardt, 1988: 136; *Nature*, 2002); for grant distribution in Canada (Berezin, 1998) and in the United Kingdom (Horrobin, 1996; Travis and Collins, 1991: 336). Similarly, interdisciplinary research has been perceived as having fewer chances in peer-reviewed grant distribution (Porter and Rossini, 1985; Travis and Collins, 1991; Berezin, 1998). Peer-reviewed grant distribution affects knowledge production indirectly by consuming applicants' and reviewers' time and money, which would otherwise be available for research (Knorr-Cetina, 1981: 28; Chubin and Hackett, 1990: 63; Lederman, 1993; Horrobin, 1996: 1294; Wessely, 1998: 302–302).

A third perspective involves changes in universities. Numerous studies have stated that the funding conditions of universities has changed (often using such catchwords as 'academic capitalism', 'entrepreneurial university' and 'commercialisation of higher education'). These changes affect research by changing academic values (Etzkowitz, 1998) and the behaviour of researchers (Morris, 2000; 2003); favouring applied research (Slaughter and Leslie, 1997); hindering 'long-termness', interdisciplinarity and diversity of research (Henkel, 2000); or promoting mainstream research rather than new approaches (Marginson and Considine, 2000).

All these perspectives black-box the mechanisms by which the funding conditions affect the content of research. The work on links between funding and knowledge growth circumvents the issue of mechanisms by treating both variables only at the macro level. The studies on peer review and university systems take scientists' statements on changed research at face value and do not investigate whether and how the supposed changes in the production of knowledge are brought about.

Studies of the changing university mostly limit themselves to the university's response to changing institutional environments. While academics' responses to new university strategies are sometimes taken into account, the outcomes of university research are not systematically investigated. The constructivist studies observe interactions between scientists and their reviewers and funding agencies but do not investigate the consequences of these interactions for the knowledge that is ultimately produced.

Another problem is that these perspectives have rarely taken into account the whole of a scientist's resource base, nor did they investigate how the reported (or assumed) changes in the content of scientific knowledge are produced. Laboratory studies contributed to this topic by showing that the content of grant proposals is subject to explicit or implicit negotiations among scientists, peer reviewers and funding agencies (Knorr-Cetina, 1981: 88-89).

However, it cannot be concluded from this observation alone that the changed proposal actually led to a changed research project. Myers' (1990) analysis of drafts of two grant proposals shows that the writing of them is an adaptation of the proposals' texts to criticisms of reviewers and 'trusted assessors' rather than an adaptation of the research project for which funding is sought (Knorr-Cetina, 1981: 53). According to his study, peer review changes the style of applications rather than the content of scientific work.

Thus, our knowledge about how funding mechanisms influence the content of knowledge production is fragmented at best, especially with regard to specific effects of particular funding mechanisms. The aim of this paper is to identify the micro-mechanisms by which scientists adapt to their funding conditions,

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and to identify the ways in which the knowledge they produce is changed.

Data and methods

The data stem from a study about the promoting and hindering conditions of external fund acquisition of German and Australian university researchers in experimental physics. The study began with the analysis of the German system of external funding that was initiated by the Deutsche Forschungsgemeinschaft. The author's move to Australia made it possible to include the Australian system as a comparison. However, any developed country whose funding system would vary in some dimensions would have suited the purpose.

Experimental physics was chosen because research in this field requires significant resources, most of which have to be available locally in the research groups' laboratories. While some researchers also used centralised big-science facilities, this was neither the common practice nor a sufficient substitute for a local laboratory. The restriction to one field limited the variance in some intervening variables such as institutions of external funding and resource demand.

Semi-structured interviews with 45 German physicists from 14 universities were conducted in 2000. Owing to Australia's substantially smaller science system, a smaller number of interviews with 21 Australian physicists from 11 universities were conducted in 2002. The following criteria were used for the selection of the scientists:

1. Variation of a scientist's recurrent funding resources: It was assumed that the level of recurrent funding influences the ability to get external funding and hence the adaptation behaviour. At German universities, only professors at the C3 or C4 level have the authority to dispose of recurrent funding.[1] The Australian system does not have these distinctive hierarchies, thus scientists from varying academic positions were selected.
2. Variation of the research age: Scientists of all career stages, from young ones at the start of their career to those at the end of theirs, were included.
3. Variation of the subfields: The physicists were chosen from different subfields of experimental physics to obtain information about the influence of epistemic conditions on resource decisions. If possible, the Australian scientists were chosen within the same subfields as the German scientists.

The interviews lasted on average one and a half hours. They were conducted as 'informed interviews' (Laudel and Gläser, 2004) and covered the following topics:

- the scientists' research trails and their origins;
- current research projects and their funding sources;
- resource needs;
- funding opportunities and prerequisites for obtaining funds from the different sources; and
- adaptations of research to conditions of funding.

The interviews were subjected to a computer-aided qualitative content analysis, using a self-developed software package based on Word macros (Gläser and Laudel, 2004). Furthermore, publication and citation data were analysed for each scientist. These data served as an additional indicator for the reputation of a scientist. It is often assumed that it is only the 'bad' scientists that have to adapt to external funding while the 'good' scientists get the money without the necessity to adapt their research. To test this assumption, the interviewed scientists were ranked according to their reputation in their scientific communities on the basis of the following indicators:

- activity as reviewer for journal articles and/or grant proposals;
- membership of editorial boards;
- membership of programme committees of international conferences;
- invited talks at the international level; and
- visiting fellowships.

Additionally, I used the number of citations received by the scientists. Citation data comprised a ten-year time span from 1990–1999 for the German scientists, and from 1993–2002 for the Australian scientists. Scientists' whole publication oeuvres over the respective period were retrieved.[2] Since the Web of Science was used as a data source, only journal articles were included. This does not pose a problem in experimental physics because articles in Web of Science journals are the dominant form of publication in this field.

I categorised the top third of each sample (15 German and seven Australian scientists) as 'top scientists' and compared them to the 'other scientists'.[3] Two questions had to be answered. First, does the adaptation behaviour differ between German and Australian scientists? Secondly, does the adaptation behaviour between the top scientists and the other scientists differ?

In the following, I will show how German and Australian scientists perceived their resource base of recurrent and of external funding and how their funding had changed. Then, I will demonstrate how scientists adapt to these funding conditions and what implication these adaptations have for their knowledge production.

Scientists' perceptions of their resource base

University researchers can access two types of funding source — recurrent funding and external funding. Recurrent funding is resources provided by the university as general infrastructure for research independent of concrete projects. In most cases, recurrent funding consists of a scientist's salary; office and laboratory space; standard equipment and its maintenance; technical support; and information and communication services. External funding refers to resources provided as a means of conducting specified research projects.

Recurrent funding

In the past, recurrent funding enabled scientists to develop a research trail by conducting research projects. It allowed scientists to apply for external funding for additional projects. This funding could be used to follow leads that emerged in the research undertaken with recurrent funding.

In Germany, the amount and specifications of the recurrent funding (so-called *Grundausstattung*¸ which means basic supplies) is negotiated when a university professor is appointed. The newly appointed professor is given scientific and technical staff, laboratory space, and research equipment as 'first supplies'. In experimental physics, depending on the specific research area, the amount of first supplies can be more than half a million Euro (personnel costs not included). Thereafter, the professor receives a certain amount of annual funding to cover:

- personnel costs;
- maintenance and (if necessary) renewal of equipment;
- consumables necessary for using the equipment (for instance, cooling liquids); and
- operating costs such as telephone costs, postage, and cost of travel.

Funds for recurrent funding are provided by the German federal states (*Bundesländer*) that finance the universities. Therefore, the funds that can be obtained by researchers starkly depend on the wealth of the federal state.

Similarly, experimental physicists in Australia get 'first supplies' in the form of research equipment with their appointment, but on a considerably lower level of funding. In contrast to the hierarchical German system, the Australian scientists usually have no authority over the scientific staff that they can use for their research projects. They might form a group of people who work together in a certain research field as equals but without 'owning' scientific staff like the German professors.

It is not common for Australian scientists to have their own research assistants. The majority of the interviewed Australian physicists had access to centralised technical workshops. Funding for maintenance and consumables was limited. A university-internal grant system exists to cover these items and small equipment.

External funding

Scientists also have access to various external funding sources. They can apply for grants that cover the cost of whole projects or they can apply for equipment grants, scholarships, travel grants and so on that cover specific costs. I will focus on the funding sources that allow financing whole research projects. Again, the external funding situation of the German and the Australian experimental physicists differ considerably.

German university physicists mainly use the six funding agencies listed in Table 1 for the funding of whole research projects. Table 1 also describes how the funding sources were perceived by the interviewed scientists (only sources and programmes that were frequently used by the interviewed scientists are included).

The Deutsche Forschungsgemeinschaft (DFG) is the only source that allows the scientists to apply for grants without predetermined topics. Within its funding scheme *Normalverfahren* (the 'responsive mode' for individual applications), there are no thematic restrictions. All other DFG funding schemes for projects require the construction of 'bottom-up' research networks with a joint research agenda, which is developed by the applying scientists themselves.

Being devoted to the funding of university research and setting no thematic limitations, the DFG tends to mainly fund basic research. Nearly all the other sources are application-oriented and sometimes require a joint application with an industry partner.

Another important dimension in which the funding agencies significantly differ is the financial autonomy they grant researchers. In contrast to the rules of the Federal Ministry of Education and Research (BMBF), the DFG was perceived as being very strict in what they fund. An attribute of funding sources that was particularly important to scientists is the amount of funding, that is, the size of the grant and the time-span of funding. To keep the costs low, the DFG usually funds PhD students as scientific personnel and often they grant only one PhD student. Therefore, the grants were perceived as rather small. The time-span of some grants is very attractive; the DFG funds research networks for up to 12 years.

Further criteria for selecting funding agencies include the effort that is needed for writing a grant application and writing grant reports; and the rough success rate for getting the grant. For example, funding from the European Union was perceived as having an extremely bureaucratic application and report procedures, combined with a very low success rate.

Funding conditions of Australian experimental physicists significantly differ from those of their German colleagues (Table 2). The physicists claimed in principle to have access to only one single funding source for whole projects — the Australian Research

Table 1. How German experimental physicists perceive their main funding sources for research projects

Funding agency	Restrictions of the research contents		Amount of funding		Financial autonomy		Efforts for application and report	Success rate (real rate in brackets)[a]
	Industry-related, applied	Predetermined topics	Size	Time span	What is funded	Flexibility of spending the money		
Recurrent funding	no	no	varying, not enough to fund a project, decreasing	permanent, yearly decisions	scientific and technical staff, limited funds for maintenance of equipment, consumables, travel	rather inflexible	–	–
DFG, *Normalverfahren* projects	no	no	small	usually 2 years	equipment and consumables if not defined as ‘basic supplies’; preferably PhD students, hardly ever technicians	rather inflexible	normal	relatively high, decreasing (64%)
DFG, funding of research networks	no	no	small	up to 15 years				lower than *Normalverfahren*
BMBF, funding programmes	industry partner needed	yes	larger than DFG	3 years	everything	better than DFG	high	lower than DFG
BMBF funding for research with big devices	no	yes, by equipment	[no comments]	up to 3 years	everything	better than DFG	normal	OK, but going down
Federal states	often applied	partly	small	3 years	everything	[no comments]	high	rather low
Volkswagen Foundation	no	yes	partly better than DFG	2–3 years	everything	[no comments]	normal	OK (45%)
European Union	industry partner often needed	yes	large	3 years	everything	[no comments]	extremely high	very low (25%)
Industry	yes	yes	small to large	varying, often short	everything	unrestricted	varying	depends on partner

Note: [a] This is the percentage of funded projects in relation to the number of project applications (sources: DFG Jahresbericht (2002: 102) for success rate in the natural sciences in 2000, the rate went down to 52% in 2004 (DFG, 2004: 92); VolkswagenStiftung, 2001 for success rate for all research fields; Commission of the European Communities (2000: 93; 2001: 29–30; 2003: 33–34 for success rate for R&D projects of the European Union 1999–2001, own calculations)

Council (ARC). Similar to the German DFG, the ARC funds single projects (‘Discovery’ grants) and ‘bottom-up’ research networks. There are no thematic restrictions, but every year preferential funding should go to so-called priority areas defined by the Australian Government. ARC Industry Linkage grants are application-oriented and require an industry partner outside the university to co-fund the project.

Several Government agencies also provide funds, but none of them was perceived as an important source of funding. Similarly, Australian industry was not perceived as a separate funding source by Australian experimental physicists because Australia lacks a high-tech industry with research and development capacities to absorb results from university research. Funding sources outside the country (including industry) played a larger role than in the German case. Thus, foreign funding agencies and collaborators can be added as an additional type of source.

Forced shift to external funding

Both German and Australian physicists assessed their recurrent funding as insufficient and many of them experienced a considerable deterioration of it. Over the last few decades, recurrent funding has decreased in German universities — personnel, equipment and material that are standard for a research group in the field are no longer financed (Schimank, 1995, Wissenschaftsrat, 2000: 11). Furthermore, there is an increasing gap between the first supplies and the means of maintaining them.

Scientists are still successful in negotiating their first supplies, particularly the money for research equipment, because the universities compete for the best scientists and thus make some effort to offer a scientist a good first supply. Problems usually occur in the years following a professor’s appointment because the university funding is not sufficient to maintain the first supply, which means that research

Table 2. How Australian experimental physicists perceive their main funding sources for research projects

Funding agency	Restrictions of the research contents		Amount of funding		Financial autonomy		Efforts for application and report	Success rate (real rate in brackets)[a]
	Industry-related, applied	Predetermined topics	Size	Time span	What is funded	Flexibility of spending the money		
Recurrent funding	no	no	very small	yearly amount	technical support; consumables; no scientific staff	flexible	–	–
ARC, Discovery	no	no	small	usually 3 years	everything, except basic technical support	flexible	very high	very low, (25%), max. two grants
ARC, linkage	yes	no	small	2-3 years	everything	flexible	high	(52%)
Foreign sources	varying	varying	varying	varying	varying	varying	varying	varying

Note: [a] Success rate for 2002 (ARC, 2002)

equipment cannot be maintained, repaired, or renewed. Often, the recurrent funding does not even cover the cost of materials and chemicals to run the machines.

If positions assigned to a group leader as first supplies become vacant because a scientist or member of technical staff leaves, they are often blocked for reappointments or even taken away. While the shift from recurrent to competitive funding is often framed as a conscious move by science policy, the fact that many German federal states cannot deliver the promised funding in spite of the resulting disturbances of research indicates that, in Germany, budget problems are the major driver of this development.

The recent funding situation is similar, or sometimes even worse, for Australian university physicists. Scientists who have received a good first supply or obtained equipment through external grants are not able to maintain it with their recurrent funding. Furthermore, they have the same problem with expensive consumables as their German colleagues. Another problem in both countries is the reduction of the technical support provided by the universities:

> We do need technicians to build some of the equipment. So we rely heavily on university infrastructure, meaning mechanical workshop people who work on lathes and with metal and so on, and electronics workshop and this is one of the biggest problems in Australia right now — that infrastructure is being cut … specialist equipment needs to be built, you can't buy it commercially. But the people don't exist in the university any more to make it. This is a big failing.
>
> Interviewer: Is this something that went down in the four years [since you have been appointed]?
>
> Oh yes, enormously, yes. I mean in real numbers we've lost 60% of our mechanical workshop and we've lost at the moment 100% of our electronics workshop. (Australian scientist)

Problems usually occur in the years after a professor's appointment because the university funding is insufficient to maintain the first supply: often, recurrent funding does not even cover the cost of materials and chemicals to run the machines

The most important consequence of these declines is that it is impossible to conduct research today solely with recurrent funding. When I asked the scientists if they could carry out one or more projects with their recurrent funding, nearly all of them said it was impossible. Australian physicists often stated that they do not get any money for research automatically but have to apply for everything (either internally in the university or externally).

Thus, while the external funding environments of Australian and German scientists markedly vary, their situation with regard to recurrent funding is strikingly similar. For both Australian and German scientists, external funding has turned from a source for additional research projects into a necessary contribution to any research a scientist wants to conduct.

As a result of both the general decline in basic supplies and the increasing gap between first and subsequent supplies, scientists are in the situation of an addict. They have begun research trails on a much better financial basis and are now driven by the internal logic of these research trails but lack the resources to follow them further. They have built up a scientific metabolism that is now deprived of one major input — money.

Scientists' adaptation strategies

Laboratory studies have shown that scientists' research practice is impregnated by a stream of choices (Knorr-Cetina 1981: 33–48). Some of these choices can be labelled strategic because they determine the mid-term course of knowledge production. These include the choice of research problems, research objects, methods and decisions about communication and collaboration (Gläser *et al*, 2002). When deciding on the content of their research, scientists also make decisions about how it can be funded. These decisions about funding are embedded in the general stream of choices that can only be analytically discerned from decisions about the content of research.

The strategies scientists applied to increase the likelihood of funding fell into two categories: targeting the resource base; and targeting the content of the research. Only typical strategies should be included, so patterns of actions were categorised as strategies only if they were consciously applied by several scientists.

Strategies targeting the resource base

Many of the interviewed scientists applied discernible strategies to acquire the funds necessary for their research. Three strategies for selecting external funding agencies could be distinguished.

Targeting 'easy' sources As has been described in the previous section, scientists are aware of the characteristics of funding sources. One attribute they take into account is the 'efficiency' of a funding source, that is, the effort required in grant writing and reporting, the success rate and the size of the grants. Applying for grants also includes effort in gathering information about the rules of the funding agency and 'learning the game'. Because of the European Union's very bureaucratic rules and its low success rate, many German scientists purposely avoided it.

> I simply don't have the time to fiddle with these things for days. And then you do things you know, and that are these programmes of the DFG, these individual projects. ('top' German scientist)

Targeting all sources The need for money made some scientists select many different funding sources to increase their research opportunities. Thus, German scientists used as many different funding agencies and as many different schemes within a funding agency as possible. The often small size of a single project grant forced the scientists to apply for additional projects. Since they cannot apply for a similar topic at the same funding agency, the scientists had to combine funding from different sources. A similar adaptation strategy was found for researchers at British universities (Morris, 2003: 366–367).

Targeting 'appropriate' sources This strategy was characterised by designing research projects first and then looking for sources of funding for these projects. This strategy presupposes both the existence of a variety of funding sources and a high likelihood of getting funded, and was therefore only used by 'top' German scientists.

None of these strategies could be applied by Australian scientists because they had only one significant source of funding, the ARC. Additionally, they had to cope with two more problems: the very low success rate, and the rule that each scientists can have only two 'Discovery grants' (the most important funding scheme for them). Therefore, many scientists desperately looked for other sources, for instance, abroad.

> Yes, there are other funding agencies and one of my things that I've been and I am working on is to diversify our funding base away from just the Australian Research Council. … our exposure and dependence on the Australian Research Council is actually dangerous in terms of long-term planning. So I have some funds that come direct from the US Government, not a lot but I am trying to build on that. There are some small university funds available to promote collaborations and we access those where appropriate. And there is new funds coming on stream to assist us to participate in European and international projects. ('top' Australian scientist)

Furthermore, the Australian scientists developed a special form for diversifying funds by using the laboratories from collaborators overseas. Quite a few Australian scientists spent several months a year in the better equipped laboratories of their collaborators and in this way extended their own laboratory. These attempts could be interpreted as an extreme case of targeting easy sources, because getting money from outside their country is apparently easier for some Australian experimental physicists than getting it from the ARC.

Scientists also tried to remain independent from funding agencies by *commercialising research results*. Several physicists owned a successfully operating company. Others had concrete plans to establish their own company in the near future. Australian scientists used this strategy to reduce their dependence on the ARC, which they perceived as the only source of research grants. Their success was limited, which the scientists ascribed to institutional conditions in Australia that hinder the process (see also Wood, 1992).

Instead of the very demanding strategy of commercialisation, many scientists applied a simple strategy of *selling services* to customers, mainly to industry. They used a part of their time for conducting routine work (for instance, measurements) that was paid for by industry. The money earned that way was especially valuable because there were no restrictions on how to spend it.

> See, sometimes I consult … industry and I earn real money. … So, here I get $1000 and I use that for buying consumables, for projects that are not funded, or to help students that don't have scholarships, and stuff like that. It works. And so, in other words, I have a mechanism of creating additional funds that I can use for unfunded projects, but they're not huge amounts. (Australian scientist)

This strategy was widespread among both Australian and German scientists. Even 'top' German scientists applied it, probably because they can use such funds without any restrictions and do not need to do the routine work themselves but can assign it to members of their group.

A last strategy is '*bootlegging*'. Scientists who wanted to try out new ideas or change their research trail and thought it unlikely that they would get funding for this research, 'rearranged' money from their externally funded projects to finance work on those new ideas (see also Morris, 2003: 364–365). This worked well as long as there were enough projects with 'slack money' at the same time and the chain was not broken, that is, as long as they were successful in acquiring project money.

> You use whatever funding you have to do something different, to explore your good idea, until you have taken it to the stage that you can get funding for it, even though the system shouldn't work like that. What you do is that you use … present funds. You have a research grant which you have funding for, you then work on that research project like you said you were going to do, but as well you use the funding in order to develop the next proposal. And you know that's the only way you can do it. (Australian scientist)

'*Free-riding*' as a further variant of actions to get funded should at least be mentioned, although it was only used by one German scientist. Having developed a special measurement method, he did not seek external funding himself but let his collaborators write the grant applications that included this method.

Strategies targeting the research content

A second group of strategies to increase the likelihood of funding was directed at the proposed research. Scientists changed the content of their research using the following strategies:

Selecting externally predetermined topics is a strategy that has to be applied when funding is tied to specific topics. This happens mostly in a top-down process, in which funding agencies define research topics and scientists try to adjust their projects (see also Morris, 2000: 433). For example, the German BMBF funding is tied to topics defined by science policy, such as, 'Application of nanostructures in optoelectronics' within the funding programme 'Nanotechnology'. Even if scientists are involved in designing these funding programmes, topics are externally predetermined for every individual applicant when the funding programme actually operates.

Science policy in Australia also defines priority research topics every year, for instance, 'Nanotechnology'. As a rule, these topics are broader than the German BMBF topics. It is not clear to what extent the ARC panel members who decide about the grants take the priority areas into consideration. However, the interviewed physicists tended to assume their fit in these topics increases their chances of winning a grant. Topics predetermined by science policy usually have an applied character.

A second kind of predetermined topic occurs when scientists collectively define research topics and form research networks. This bottom-up approach, which can be found in Germany and in Australia, is much more convenient for scientists. However, they must adapt to the topics of their colleagues.

The same happens in collaborations based on stays in other laboratories. Australian scientists had to adapt their aims, methods and/or research objects to collaborators when they worked in overseas laboratories, an adaptation that these scientists perceived as an unwanted side-effect. One Australian scientist has changed his research trail toward big devices research because he found it easier to obtain funding for this kind of research. Thus, he had to choose topics where the method was predetermined:

> That's why I work overseas. I have moved into doing neutron scattering stuff …, because I can't work in Australia. So, that's why I do those things. I don't do them just because I want to. … But we do that because I have not been able to get funding to work in Australia. It's not only the absence of facilities. If I could get funding to work at [this] University, I would be doing different things to what I am doing now. So, things have evolved along this path because I can get money to work overseas. (Australian scientist)

A specific variant of the adaptation to collaborators is the adaptation to industry partners. In these cases, there is little room for negotiation. Industry partners would not finance topics in which they are not interested. German interviewees often had to adapt to industry partners because they needed them to get BMBF funding.[4]

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The degree to which a scientist has to adapt depends on the fit between his/her research trail and the topics for which funding is provided, or that are regarded as important by his/her community: it is also influenced by the specificity of the topics

are regarded as important by his or her community. It is also influenced by the specificity of the topics; broader topics (like the ARC priority areas) make it easier to match one's present research work or to window-dress it. In the case of bottom-up topic selection, it depends on a researcher's role in the definition of the topic.

Thus, the whole spectrum from 'no adaptation/window-dressing' to 'strong adaptation' occurs. Adaptations to predetermined topics were even welcomed by scientists when the latter fit with their own research interests and promised new opportunities of collaboration, as in the case of research networks. Consequently, such adaptations cannot always be interpreted as an unwanted side-effect.

Diversifying research To get a project funded, scientists must prove that it is sufficiently different from all the others for which they are already getting money. Therefore they diversified by including additional topics and objects in their research. Diversification was also a secondary effect of adapting part of the research to predetermined topics.

Avoiding risky research The interviewed scientists assumed that risky research would not be funded. They stated that new ideas where one is unsure whether it will work cannot be included in a grant proposal. Scientists reported that they had failed by applying for 'innovative', 'exotic', or 'risky' projects. Interdisciplinary projects also fall in this category, because they are often perceived as risky. The interviewed scientists referred to the funding agencies' requirement to prove the credibility of a proposal by describing the previous work conducted on the topic.

> I think I never sent a project to the DFG where I could not include at least two publications as prior work on the topic, because I took the view that you have little chances to get through with it … If you have something completely new then do it with any money you have for something else. Just try it. But don't go to the DFG and ask to get money for that. ('top' German scientist)

Avoiding 'hot' topics Australian scientists had to cope with the inflexibility of most ARC grants' procedures where application is once a year in February for grants that start in January the following year. The combination of this funding procedure with an infrastructure that does not enable projects without external funding, led some scientists to select niche topics instead of trying to compete in a field in which many scientists internationally were working.

> I don't think we're well enough funded to be able to compete right at the very cutting edge … well, basically, because we don't have the infrastructure and anything like the funding which the big American labs have. And so, we can't jump into it pretty well as quickly as they can. If we decide to do something and say you apply for an ARC grant in January, something like that, and you find out whether you're successful in November of that year, the money starts in the January and then you can start ordering equipment and so on. So it's really at least 18 months between deciding to do something and actually beginning to really do it and that doesn't allow you to get a long way ahead. ('top' Australian scientist)

Scientists also selected 'cheap' research in anticipation of what is likely to be funded by adapting research methods and objects. Additionally, downsizing of projects was practised by all groups of scientists because of the limited grant size and because grants are often cut. A more radical variant was the adaptation of methods and objects. For example, Australian scientists changed their methods by shifting from expensive to cheaper laser techniques.

> Even with lasers, I work with lasers, every year there's newer and better and higher powered and different wavelength lasers coming out. It would be nice to have access to these but we know we can't afford it because a new laser costs 200 thousand dollars. My grant for three years is 200 thousand dollars and I have to pay two postdocs and so on. ('top' Australian scientist)

Impacts on individual knowledge production

As described previously, all scientists are forced to apply for external funds because their resource base is insufficient to conduct research. Furthermore, external funding is not just an additional, but the main, funding source for German and Australian university researchers. The impacts on knowledge production are caused by this necessity to use external funds to conduct research and by the adapting behaviour that follows. The effects that were reported by the scientists, can be roughly differentiated into five groups.

Decreasing quality Several quality-related aspects were mentioned by interviewees. Research slowed down because of the amount of time needed for applying and the decision process, the severe funding cuts, and the failure to secure funding.

> And if and when there has been funding, it's usually inadequate because you never get what you ask for, and that means that things are delayed while you try and fit the project in to the available funds. So, I've had funding to set up a new laboratory to do work in [a certain research area], and that's taken — it's five years since I applied, and it's perhaps almost complete. But I've almost forgotten why I wanted to do it because … it just took so long to get the $300,000 required to set up the lab — it just took so long and was so hard to acquire the money slowly and painfully. (Australian scientist)

As in the quoted example, Australian scientists could take a rather long time to set up a laboratory because there is usually not an automatic supply of equipment with a researcher's appointment as in the case of the German professors. In extreme cases scientists had to leave the research front because of insufficient funding.

More specifically, the downsizing of projects adversely influenced the quality of research. Australian physicists were more strongly affected because they could hardly compensate for cuts in grants by applying to other funding sources.

> You know, you ask for 100,000 and they give you 60,000 or you ask for 120 and they give you 80. So then you have to cut things out of your budget and you have to kind of modify what you want to do. And they don't give you any explanations or things, you've just go to do it, you know, so it's very frustrating. They have this pretence that they fully fund but they don't and … you're always having to modify what you really want to do to what they've given you. So that's, I suppose, been the major problem. You know, they never quite give you enough funding.
>
> Interviewer: What does it mean for your projects? I mean, if you apply for 100,000 and you got 60,000, what did you have to change?
>
> One time we had put in for a postdoc and so we had planned activities which were obviously based on having this person. And so suddenly you have to truncate what you can possibly do. So you cut out that part of the programme which you hoped that that person was going to do. (Australian scientist)

A serious implication of the cuts in project funding by funding agencies is the resulting reduced variety of methods. This may affect the quality of results when several methods are necessary to validate a finding.

> There are always projects where you would like to reproduce things, where you would like to make it more reliable but you can't because that would require additional technical effort that you can't realise with your in-house money. Mostly you help yourself by going to somebody and conduct a collaboration or something like that. But if you want to do it routinely then you can't constantly bother the others by coming with something and wanting to use their equipment. However, many things have to be checked routinely; this simply increases the reliability of the results. You can't always do that. That means you have somehow to compromise about what you can still publish with good conscience even if not all checks have been done due to a lack of instrumentation. ('top' German scientist)

As an effect of adapting to predetermined research topics, scientists had to use inappropriate objects, for example, objects that were too complex or too 'dirty' for the applied methods. Furthermore, any change of topic that was enforced by the necessity to get funded may lead scientists into research not in accordance with their research interests. Such a discrepancy between interests and aims endangers research quality, because it is often connected with leaving one's area of expertise.

> If the semiconductor industry announces something in this direction — at the moment there is a lot about thin layers — then one has to adapt in a certain way. I mean I always had to do this over the years because you need to get money from somewhere … Well, I would prefer to do certain things where my strengths lie, honestly speaking. And in an area that you enjoy considerably more, there is much more coming out compared to a situation in which you are forced to do something just to keep the group together and to keep a certain critical mass. (German scientist)

All four groups of scientist had to cope with quality problems although to different degrees. Both top and other scientists were affected by the slowing down and downsizing of projects, and the restriction of the variety of methods. However, no 'strong' adaptations with the resulting mismatch of projects and research interests, or work on inappropriate objects were reported by top scientists.

Innovations in research The scientists stated that they were not able to change their research trails, because this would require a change in the standard equipment. German scientists said that they could change their research trail when they were appointed as professors. Many of them could substantially broaden their research base in terms of methods. However, after the appointment, change becomes impossible. Continuity of research trails is also enforced because it is usually a prerequisite for getting external funding (see also Hackett, 1987: 144–145, Mukerji, 1989: 103–104).

> Problems emerge as soon as you intend to change your research area. Last time you have this opportunity is at the time of your appointment. And the decision practice of funding agencies is that I only get grants where I have already done some work. See, that's the 'catch 22': I would need external funding to start something new, but since I haven't started the new thing, I can't get external funding. (German scientist)

The combined lack of recurrent and external funding led scientists to discontinue current research topics.

> And at the same time there was no money for a long time from both the Federal states and at the universities (they have decreased in the last 20 years to a third) as well as at the external funding agencies … And this made us withdraw from the field of laser spectroscopy and more or less solely oriented to applied spectroscopy. (German scientist)

> I will probably stop doing the … scattering experiments because, yes, I can't get funding to do that. I've tried a number of times. I've tried in collaboration with other leading scientists in that area in Australia and almost no grants in the last ten years have gone in that area. (Australian scientist)

Initiated research ideas and projects died if a scientist failed to get a grant. With the scarcity of resources, the rejection of a grant proposal affects not only grants for poor quality research but also research work that is worth funding (Chubin and Hackett, 1990: 60–73). For both German and Australian scientists, it was difficult to pursue projects that were rejected in the first instance; in Australia, because there are hardly any alternative funding sources;[5] in Germany, because there is only one funding agency for basic research (the DFG).

> You are not allowed to try twice. Like the eagle, if he misses, he has to fly up again, and has to let the lamb go. It is the same way with the DFG. You never get a second chance. (German scientist)

The scientists' perception that it is hardly possible to get funding for risky research has resulted in this kind of research being disadvantaged. Similarly, new ideas suffered because they were 'too new' for external funding and recurrent funding was insufficient to realise them. A way out was to test new ideas by either bootlegging or using the equipment of colleagues, and then apply for external grants. Although these loopholes exist, the scientists still reported that they could not get funding for new ideas. Acquiring external funding was especially difficult in the case of interdisciplinary research, because it needs much more time and effort to get such ideas to a stage that would convince the referees to fund it.

New ideas suffered because they were 'too new' for external funding and recurrent funding was insufficient: a way out was to test new ideas by either bootlegging or using the equipment of colleagues, and then apply for external grants

The tendency to tie funding to predetermined topics and the low success rates of many funding programmes hinder research outside the mainstream. The scientists stated that scientific fashions are favoured. However, German scientists could still find funding for non-mainstream projects within the DFG *Normalverfahren* programme because it is not predetermined and its success rate was still high.

Another problem is that new aspects that occur during a project could not be pursued because in experimental physics this would often require additional equipment.

> You are, for example, in a Collaborative Research Centre with a certain project. Then you realise that you need an additional device which you didn't know before. This is rejected or can't be funded. Then you must drop this new aspect that you discovered … not that the whole project breaks down, but only some new aspects are suppressed because it is impossible to get this [device] subsequently. (German scientist)

Disappearance of slowly progressing research

Scientists did not in principle feel restricted in conducting long-term research. They could successfully pursue topics for a long time by writing follow-up grant proposals. This worked if they successfully produced results and as long as there was no gap in the grant chain.

However, the heavy reliance on grants hindered long-term research in two different ways. First, the transfer of know-how was endangered when long-term research was undertaken as a series of consecutive grant-funded projects. In many cases, the scientists lost specific know-how because there was a gap between grants, that is, when the grant-funded carrier of that knowledge (a PhD student or postdoc) had to leave before the next grant started and a new researcher was appointed. Without recurrent funding that could bridge a gap between two grants and thus secure the know-how transfer, this knowledge was lost.

Secondly, the scientists had to present funding 'success' to get a follow-up grant or another project. After a two or three-year time-span of funding and prior work successfully done, long-term research that does not produce results quickly would not be funded.

> The money is scarce and you are measured very hard. If there weren't many results in the first three years and you couldn't make clear that the area is exciting then you are a has-been. We are more and more forced to work like in America, that is to produce publications as quickly as possible. And this is tricky, this is not easy. And what you nearly can't do at the university is long-term projects where you need a long time, until this is running and until it produces first results … ('top' German scientist)

Both German and Australian scientists found it difficult to get funding for the development of methods and instruments. This was partly because of the lack of technical support through the university, and partly because of difficulties in getting funding in this area. It can also be assumed that the development of methods belongs to the type of long-term research that does not produce results quickly.

Shift to applied research Many German interviewees perceived that their research trail had changed from basic to more applied. This shift was caused by the lack of recurrent funding and the special rules of the DFG as funding agency for basic research. The DFG does not fund certain equipment, consumables and technicians that it considers as basic supplies.

If the recurrent funding was too low to finance basic supplies, scientists had to look elsewhere for 'flexible' money that could be used. This can be found in programmes with externally predetermined, application-oriented topics offered by funding agencies such as the BMBF. An unintended shift to applied research as a consequence of externally predetermined topics was also observed for bioscientists (Hackett, 1987: 142–143).

Change in the experimental/theoretical character of research A German experimental physicist reported that his research had changed to a more theoretical direction because of his difficulties in getting research grants. The research of some Australian physicists moved in the opposite direction. To acquire the urgently needed equipment, these physicists used the two grants they can hold according to the ARC's rule to finance their experimental research. Since they could not obtain any more grants, they had to cut down their theoretical research.

A general but crucial aspect is the reduction of time for research. The majority of the interviewed scientists bemoaned the huge amount of time that is wasted preparing grant applications and grant reports and managing grants. In their opinion, the waste of time outweighs the positive effects of writing grant applications, that is, the necessity to conceptualise vague ideas.

Discussion

Before we turn to the discussion of results, a methodological comment is necessary. Why should we believe scientists' accounts of their funding situation and responses? Since scientists usually have more ideas than they can actually fund, they tend to complain about their funding regardless of how much they receive. Furthermore, they might use accounts such as 'the research was too risky to get external funding' as an excuse for unsuccessful fundraising.

The interviews contained an in-depth discussion of a scientist's current projects, and further inquiries, for instance, about the nature of the risk, mentioned as a reason for not applying or not getting funded. By forcing scientists to give detailed scientific accounts of their successful and unsuccessful projects, superficial retrospective rationalisations could be deconstructed. Furthermore, accounts that could not be unambiguously interpreted were excluded.

A more general argument against the assumption that scientists' accounts are mere misperceptions and excuses for failure is that, in this case, we would expect to see more differences between 'top' and 'other' scientists than were actually observed. The descriptions of funding conditions, adaptive behaviour, and consequences for knowledge were consistent within and between the four groups of scientists.

Finally, rejecting scientists' accounts as mere shifts of blame would mean accepting an alternative hypothesis, namely that scarcity of funding does not affect scientists' behaviour, either because there is no such scarcity or because the influence of scarce funding is overridden by other factors. Either alternative explanation lacks empirical support.

Both German and Australian experimental physicists depend on external funding for their research projects. Therefore, the scientists have to cope with the practices of funding agencies such as externally predetermined topics, evaluation of their projects, competition with their colleagues, rejection of proposals, and scarce resources. They have developed strategies for approaching possible sources of funding and for shaping their research projects in a way that increases the likelihood of funding success.

These strategies vary according to the conditions under which scientists act (Table 3). Strategies of selecting funding sources presuppose a funding

Table 3. Adaptation strategies and effects on the content of research (white fields mean they were not mentioned)[a]

		'Top' German scientists	**German others**	**'Top' Australian scientists**	**Australian others**
Adaptation strategies targeting the resource base	Targeting 'easy' sources	■	■		
	Targeting all sources		■		
	Targeting appropriate sources	■			
	Commercialising results	■		■	■
	Selling services	■	■		■
	'Bootlegging'	■	■	■	■
Adaptation strategies targeting the research content	Selecting predetermined topics	■	■	■	■
	Avoiding risky research	■	■	■	■
	Diversifying research	■	■		
	Avoiding 'hot' topics			■	■
	Selecting 'cheap' research	downsizing	■	■	■
Effects on the research content	Decreasing quality	■	■	■	■
	Decreasing innovativeness	■	■	■	■
	Disappearance of slowly progressing research	■	■	■	■
	Shift to applied research	■	■		
	Change of the experimental/theoretical character of research		more theoretical	less theoretical	less theoretical

Note: [a] The exact number of interviewees that mentioned a strategy or an effect is not listed because the strategies were probably implied more often by the interviewees than they were reported in the interview (see the methodological discussion)

environment consisting of a range of sources with varying attributes. In Australia, where experimental physicists depend on a single source of funding, no such strategies could develop. The only signs of a variation in strategies were Australian scientists' attempts to use foreign sources, thereby creating a more diverse funding environment.

The high pressure exerted by a dependency on a single source might be a reason why attempts to commercialise research results are more widespread among Australian experimental physicists, while commercialisation is restricted to top scientists among German experimental physicists. Diverting time and resources to 'making money' by selling services is common in both Australia and Germany, that even 'top' German scientists confirm doing so might be explained by the fact that these scientists are group leaders who could delegate these tasks.

Scientists of all groups resort to bootlegging, that is, using money paid for other tasks to do what they think is important. This behaviour is enforced by a situation where 'correct' spending of money does not enable a continuous fruitful research process.

The strategies for adapting the content of projects also reflect the different funding environments of Australian and German scientists. Diversifying research by increasing the number of one's distinguishable topics of research only makes sense if a variety of funding agencies exists, and if multiple funding of one and the same project must be avoided. It was therefore found only in Germany.

Similarly, the slow processing of funding applications by a single Australian funding source made Australian scientists avoid 'hot topics' that would require quick reactions to changing research fronts. The trend towards 'cheap' research was ubiquitous, with top scientists choosing a downsizing of their projects rather than changes in content, while other scientists used all changes available.

Table 3 shows that all scientists adapt. However, German 'top' scientists undertook less severe adaptations than other German scientists. Such a difference could not really be found for the Australian case: this can be explained by the poorer resource situation.

The funding situation and scientists' responses to it could be expected to affect the content of knowledge production. The results of the peer-review studies discussed in the beginning were confirmed: risky, non-mainstream, interdisciplinary research is hindered. My study enriches these findings by showing the causal relationships of the combination of recurrent funding and external funding and the causal mechanisms (adaptation activities) that create these effects. It also revealed that the categories to describe properties of the research content are still too fuzzy to catch the subtle changes occurring.

For example, there were sometimes ways to conduct certain 'risky' research, while other 'risky' research would not be carried out at all. What distinguishes the former from the latter, must still be specified. Furthermore, it is often assumed that external funding hinders long-term research. However, some of the interviewed physicists stated that they are able to maintain long-term research trails by constructing a patchwork of projects. This indicates that it is not long-term research in general that is hindered but a specific type of long-term research, namely research that does not produce results in the time frames of individual projects. To differentiate these categories requires an interplay of theoretical and empirical research.

Several adverse aspects could be identified, which are related to the quality and innovativeness of research. Apparently, the agility and flexibility that is demanded from researchers to obtain funding has the reverse effect on their research. Research that is constantly hunting for its own funding becomes slowed down, sluggish and sclerotic. The only significant difference between trends in Germany and Australia can again be explained by the differences between the funding environments. German industry exerts a strong pressure towards applied research, both by its own funding and via the funding by the Research Ministry that aims to support industry. In Australia, these conditions do not exist to an extent that could direct research in experimental physics.

So far we have regarded the effects of the funding environment on the individual researcher. However, what is constraining the individual researcher does not necessarily hinder the progress of a whole scientific community. A scientific community always has to act under the conditions of limited resources. Therefore it directs its members to select topics and to design research regarded as necessary by the community. The scientific community's peer-review mechanism of projects fulfils this function by adjusting the perspectives of the single researcher to those of the scientific community (Gläser, forthcoming: 99–104).

From the perspective of a scientific community, peer review is a mechanism that leads to the funding of the most promising projects, and avoids researchers leaving their area of competence. However, it is the apparently random search that enables fast progress under conditions of extreme uncertainty. In shepherding its researchers towards the mainstream, a scientific community restricts unorthodox perspectives, which have always been important for the progress of science.

In shepherding its researchers towards the mainstream, a scientific community restricts unorthodox perspectives, which have always been important for the progress of science

What appears as the contradiction between scientists' desire to realise all their ideas and the wisdom of the community's majority represents the trade off between 'possibly fast' and 'slowly, but safely'. The interesting twist in this development is that the individual scientist's autonomy is endangered not by the state, the military, or the economy, but by his or her community. Only a certain degree of autonomy from the community makes it possible for the individual researcher to develop unorthodox perspectives and ideas. The macro-effects of the micro-level adaptations and of the lack of autonomy from one's community remain to be studied.

The investigation was undertaken for experimental physics, a resource-intensive field, and the funding conditions of two countries were compared. The scope of the findings can be extended to other research environments with similar funding conditions (low amount of recurrent funding, high pressure to use external funding) and other resource-intensive fields, for instance, other experimental sciences.

While the study revealed interesting insights into scientists' strategies and their effects, it also showed the limitations of the interview method. Scientists often seem to be unaware what effects their adaptive behaviour have on their research, especially because adaptations are a gradual process. This is in accordance with laboratory studies, which have shown that decisions are made by scientists as part of their everyday work, and that at least some of these are made without consciously considering their impact on knowledge production.

It is most likely that the adaptations and their effects described in this article are only the tip of the iceberg. Subconscious adaptation processes cannot be studied by using interview methods alone. Even adaptation processes that have been described by the interviewees must be regarded with caution. Ethnographic observations of scientists' practices have to be included in order to investigate the aspects that cannot be communicated (Gläser *et al*, 2002: 35– 36).

Conclusions

This study has shown that the current funding conditions, under which all research is conducted in the form of competitively funded projects, promote low-risk, mainstream, 'cheap', applied, inflexible research. Scientists' adaptations to the institutional conditions of funding not only have the intended effects of directing research and increasing quality, but have widespread side effects that, in the perceptions of scientists, restrain the quality and innovativeness of their research.

While the complaints of scientists are well known, three major qualifications can be made on the basis of this study. First, the assumption that scientists' complaints refer to real processes can be reinforced. Most of the prior research relied on surveys that came close to opinion polls (see Gläser *et al*, 2002 for an extensive critique). By linking scientists' perceptions of funding conditions to adaptation strategies and then adaptation strategies to changes in the content of research, the mechanisms that lead to changes in the research content can be identified.

Secondly, I have shown that it is not a specific regulation or funding system that produces these effects, but a situation in which scientists completely depend on external evaluations to acquire their funds. While adaptive behaviour is specific to individual funding systems, changes in the content of knowledge depend on scientists' response to the totality of their funding situation.

Thirdly, the widespread assumption that only mediocre scientists respond to difficulties in getting funded by adapting their research has been proven wrong. All scientists are affected. Excellent scientists are able to avoid some of the worst effects because they can more often choose between funding sources rather than change their research content. On the other hand, they seem to feel the effects of forced adaptations more strongly because they have a research programme that they want to realise and are less willing to compromise on their research by changing its content.

The adaptations and effects discussed in this study hint at three long-term trends that merit closer attention. First, researcher's essential dependency on external funding has assigned a new function to external funds. Beside its original function to enable new lines of research, external funding now also finishes existing lines of research that cannot be pursued by recurrent funding.

Secondly, the function of external funds has changed from enabling additional research to enabling research to be conducted at all. Research is no longer purely autonomous in the sense that a researcher can decide about projects independently of his or her colleagues. All research needs external funds, and external funds are only provided for projects that have been submitted to the scrutiny of others. It is this loss of autonomy that ultimately creates risk avoidance, clinging to the mainstream and thus a loss of innovativeness.

It must be emphasised that it is not external funding that causes these adverse effects, but the combination of the lack of recurrent funding and external funding with its special conditions. This brings us to the third and possibly most dangerous long-term trend. For the international science system as a whole, the adaptations described for German and Australian scientists would not be problematic if they are few in number and counteracted by different adaptation processes in other countries. For example, the shift to applied research in Germany would not be a problem if counteracted by a shift to basic research in other countries. However, from the empirical results, it is doubtful whether the aggregate outcome of adaptation processes is nil. If there is a trend towards a standardisation of national science policies with regard to both their institutions and their priorities, it will endanger the 'requisite variety' of national institutional environments.

Given the necessary resources for scientists to follow their creativity, there is nothing that science needs more than variety. With the worldwide tendency to cut recurrent funding and to extend evaluation-based funding mechanisms, there is a threat that certain types of research will be disadvantaged everywhere. 'Crazy ideas' (anything whose success is difficult to predict); spontaneous, 'playful' research, changes of research trails, and the search for new connections between fields might become 'endangered species' in science.

Notes

1. Some specific features of the highly hierarchical German science system must be taken into account. While C4 professors (chairs) and C3 professors are usually both independent researchers, C3 professors get significantly less resources. Scientists below this level are regarded as 'up and coming' scientists who are still in an educational phase. They are formally (and in most cases also in fact) dependent on the university professors, even if they obtained their PhD a long time ago. The easiest way to make this specific hierarchy internationally comparable is to regard German university professors as leaders of research groups of different sizes.
2. Against the general methodological rule, citation analyses were used at the level of individual scientists. However, this approach can be justified because: citations were cumulated over a relatively long time-span; the indicator was used in connection with a considerable number of other indicators; and it served as a rough distinction between two groups rather than a fine-grained ranking of individual scientists.
3. A reviewer pointed out that this distinction might be distorted by the age of the scientists. However, for the purposes of this investigation, it is not important whether scientists have not yet achieved 'top' status because they are too young. Nevertheless, young scientists were among both German and Australian 'top' scientists.
4. In recent years, there has been much concern about the impact of university–industry ties on university research (see, for example, the contributions in Croissant and Restivo, 2001). Most of the discussion focuses on commercialisation and the related issues of changing values (Etzkowitz, 1989; 1998) secrecy (Blumenthal *et al*, 1997) and so on, which are not directly linked to the adaptation processes discussed here, but may indirectly contribute to them.
5. Because of the big gap between the number of projects worthy of funding and the amount of money actually available, ARC grants can be resubmitted. This could prevent the death of some research ideas, but many would die nevertheless.

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