



Production of Knowledge Revisited: The Impact of Academic Spin-Offs on Public Research Performance in Europe (PROKNOW)

Final Report

**Jörg Potthast
Social Science Research Center Berlin
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**Coordinator:
Social Science Research Center Berlin
Research Group Science Policy Studies
Andreas Knie and Dagmar Simon
Reichpietschufer 50
D - 10785 Berlin
dsimon@wzb.eu**

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Contents

Executive Summary	5
1. INTRODUCTION	11
a) Outline of the report	12
b) Entrepreneurship-based science?	15
c) Has interaction between science and industry become more intensive?	16
d) Industrial research as an object of research.....	19
e) Commercialisation of science and its discontents	20
2. LANDS.....	24
a) IT Land, BioLand, NanoLand: Exploring high concentrations of academic spin-offs	24
b) Barriers	26
3. INTERACTIONS.....	29
a) Complex coordination	30
b) Interaction as a catalyst.....	32
c) The role of intermediaries	34
4. REPERCUSSIONS.....	36
a) Repercussions according to the input model of science	36
b) Repercussions according to the output model of science	38
c) Who is really doing science-industry, except a few (male) professors?	41
d) Caveats.....	42
5. CONCLUSIONS	44
a) Rise of entrepreneurship policy or another spectre haunting Europe?	45
b) Absence of bad repercussions? Are academic spin-offs always good for science?.....	46
c) Incentives for transfer?	47
References	50
6. ANNEX.....	55
a) The PROKNOW research teams.....	55
b) Key documents	57

Executive Summary¹

Abstract

Academic spin-offs are private firms founded in direct connection with a transfer of knowledge or technology from public research facilities or universities. This direct relationship is established through patents or persons who transfer to the spin-off. Based on this definition, PROKNOW has analysed interactions between public research institutions and academic spin-offs. Closely looking at a limited number of cases, a broad definition of "interaction" has been applied which includes flows of people (between both types of organisations), joint activities of knowledge production, and flows of monetary resources. With regard to three areas of research and innovation, namely IT, biotechnology and nanotechnology, the analysis of interactions has enabled the establishment of a finely grained picture of repercussions resulting from various forms of interaction. The analyses undertaken by PROKNOW research teams in Germany, France, the UK, the Netherlands, Switzerland, Finland, and Bulgaria are based upon approaches in the economics of innovation, organisational sociology, studies on higher education and science studies.

Objectives of the research

The objectives of the research project have been twofold. Generally speaking, the project aims at re-conceptualising science-industry relations along the "interactive model". Related to that, the second objective is rather specific: PROKNOW has brought the "interactive model" to an area of research and policy which has been largely dominated by the "linear model".

Re-conceptualising science-industry relations has proved to be a demanding task. On the one hand, despite many criticisms, the "linear model" is still alive. On the other hand, a number of alternative approaches have been presented. Broadly speaking, their common goal is to promote an "interactive model". While the linear model presupposes that knowledge trickles down from science to its industrial application, the interactive model emphasises on two-way traffic

¹ Large parts of this executive summary have been taken from the "PROKNOW policy brief" submitted to the European Commission by 15 December 2008.

including the dimensions just mentioned (people, joint activities of knowledge generation, monetary resources). Taking interactions between academic spin-offs and their parent institute as a subject of investigation, the PROKNOW research project has decided to take the "interactive model" of science-industry relations seriously, i.e. to bring it to the light of empirical analysis. Presenting a framework for empirical analysis, we escape from the normative assumptions which have accompanied the rise of the interactive model and possibly detect (positive and negative) impacts resulting from sustained interactions between both parties. Turning to the interactive model, we have adopted a perspective on academic spin-offs which is unlikely to contribute to the question of their economic success or survival. Instead, PROKNOW has systematically explored how academic spin-offs relate to their context of origin, i.e. the scientific field. *To put it more technically, the project has sought to identify interactions between academic spin-offs and their parent institutes and to assess the impact of this interaction (on the parent institute).*

Scientific approach / methodology

The project is situated in a research field which has repeatedly raised the following issues. First, a number of studies claim that interactions between science and industry have intensified and forms of interaction diversified. Second, industrial research has been repeatedly found to be a vanishing object. Research activities carried out by smaller firms are especially difficult to capture. Third, a bulk of studies has taken a critical perspective towards old and more recent trends of "academic capitalism". PROKNOW offers new insights with regard to all of these issues. It borrows from and relates to several fields of scientific research; science studies, innovation economics, organisational sociology, and studies on higher education.

As a unit of analysis, the project focuses on links between two types of organisations, namely public research organisations and firms which originated from them. To explore these interactions, a matrix has been developed which is divided into three basic dimensions; interaction in terms of people, in terms of joint activities of knowledge generation, and in terms of monetary resources. Following a common strategy of sampling, the consortium has covered a variety of types, both on the side of spin-off companies, and on the side of parent institutes. More specifically, having decided to study only top concentrations of spin-

off activities, the project has focused on a small number of (five) case studies (per country), embracing the areas of IT, biotechnology and nanotechnology. The main source for empirical analyses has been semi-structured interviews with CEOs of spin-off firms and representatives for the institute of origin who have been involved in the spin-off process (more than 250 interviews altogether). This material was partly coded and interpreted with the support of software for content analysis. Departing from a small number of pilot studies, a multi-stage collective process of qualitative research was carried out and helped to identify key dimensions of interaction and repercussions. Departing from the usual approaches which tend to observe interactions either at the level of individual researchers or that of entire research organisations, departments or universities, PROKNOW has focused on interactions between academic spin-off companies and research groups. With regard to this particular level, the inquiry has shed light on the conditions for agenda overlaps, on the generation of new contacts in science and industry, and on the role of intermediaries such as technology transfer units fostering or buffering interactions.

New knowledge and European added value

Empirical findings show that intensities and patterns of interaction vary along the lines of the mentioned areas of research and innovation. While this features as a first finding and overall pattern, a second finding points to a transversal dynamics: if academic spin-offs are involved in developing generic technologies, their institutes of origin are most likely to be affected by repercussions, reaching the level of research technology. Third, while the overall picture shows low levels and intensities of interaction, having been involved in the creation of a spin-off company is frequently reported to have long term consequences. Even a one-off experience can imply that the "market test" has been passed and facilitates access to current public funding schemes. Fourth, notwithstanding this indirect sort of impact, it was not observed that interaction resulted in shifting research agendas of public research organisations towards the applied side of science. Also, in contrast to a wide-spread interpretation, we cannot confirm that research institutes engaging in spin-off activities, be it for the purpose of patent portfolio management, would inevitably end up as more centralised or corporate-like organisations. Rather, we claim that another aspect of repercussion is more relevant. To borrow a term frequently used by participants, we have found a (male) professor-centric pattern of the way academic spin-offs

relate to their parent institutes. This insight leads us to reconsider spin-off processes in terms of domestic relations. To a considerable degree (and depending on institutional layouts and national academic cultures), doing science-industry depends on a single person. In systems of research and higher education which provide professors with high degrees of freedom, we are therefore confronted with a counter-intuitive finding: by creating spin-offs, a research group may stabilise old school domestic types of social hierarchies.

Key messages for policy-makers

Public policy has often failed in creating conditions under which private companies do more research. This is held to be a key for securing their competitiveness and the competitiveness of European economies. More recently, this problem has been tied up with the issue of cooperation between private firms and public research organisations.² Would closer cooperation result in transforming research organisations? Would it produce measurable effects in terms of scientific and industrial innovation? Would private firms more closely linked up with public research organisations end up increasing their research budgets?

A large number of recent policies have been justified by referring to the interactive model. With regard to our subject of analysis, interactions between academic spin-offs and their parent institutes, we recommend to scale down political expectations attached to the interactive model. Academic spin-offs should no longer be regarded as another possible “solution” to the problem of European knowledge societies faced with a rising pressure to innovate. If policy frameworks were designed to promote that solution, they are likely to fail or to create reverse effects. In order to encourage close interaction at the interface between academic spin-offs and their parent institutes which might either replace or stimulate private investment in research, more attention needs to be given to the immediate context of origin of the spin-off firm.

Two simple recommendations can be formulated: First, do not expect interaction (between academic spin-offs and their parent institutes) to result in higher

² Cf. for instance the *Five-year assessment of the European Union Research Framework Programmes, 1999-2003* published in 2004: “In a knowledge-based economy innovation depends critically on collaborative networks involving academic and business enterprise research” (<http://ec.europa.eu/research/reports/2004>).

research expenditures by private companies and a significant source of funding for research organisations. Second, do not expect high levels of interaction between both parties unless this has a rewarding effect for the immediate context of origin of the academic spin-offs. – Reformulated in positive terms, we suggest that there are two policy options which are not necessarily mutually exclusive but should be jointly considered. In the line of the first recommendation, we suggest to tighten the policy agenda with regard to economic and industrial policy goals: identify the few areas which are most likely to produce a financial return for parenting research organisations and provide for large incentives. In the line of the second recommendation, it should be considered to broaden the policy agenda with regard to science policy goals: adjust any new action to foster interaction (between academic spin-offs and their parent institutes) to the particular institutional layout of the public research organisation.

Following this outline of policy options, we conclude by providing a scenario which is likely to develop if there were no policy change. We expect practitioners to reflexively appropriate this scenario and leave them the task of designing policy measures at a more detailed level. If we are correct to observe that universities and public research organisations are currently taking up a more active role in defining their profiles, our recommendations should be addressed primarily to the heads of these organisations.

Well known sector characteristics like "capital intensity" and "time to market" are relevant. This is reflected by higher intensities and more sustained levels of interaction in the related fields. Speaking of sector characteristics (Malerba 2002), we have rarely encountered academic spin-offs that defy sectoral boundaries. Far from being drivers of sectoral change, academic spin-offs occur as part of various processes of intra-sectoral reorganisation (outsourcing, etc.).

Looking at the overall picture, "interaction" remains fairly confined. It takes place on a regular and institutionalised basis but is often limited to senior staff of the research institute who have a mandate in the spin-off's consultancy board and are in charge to "report from new developments". In most cases, "interaction" is a matter of keeping the person "on board" who has been at the origin of the idea leading to the creation of the spin-off. To be "kept on board" generally means to be offered shares of the company. In exchange, the person commits him/herself to an often long and complicated process of clarifying the patent

situation. Obviously, this kind of arrangement only comes up in cases where property claims matter, especially in the field of bio-therapeutics. Beyond these fields, "interaction" is not used as a category of "action" which could be further specified. It is rather understood as a category of disposition. Some academics who have been involved in "interaction" may behave "differently" but there is no need to question a simple model according to which academics may either display a disposition or the absence of a disposition to get involved with industry.

If no policy change is taken who will actually be doing science-industry tomorrow? The answer is disillusioning: no one except a few co-founding (most often) tenured professors. In terms of publications and their impact, some of them are "star scientists". Regarding the case of this small subpopulation, interaction (between academic spin-offs and their parent institutes) has been found to have a positive impact: Star scientists who get involved in spin-off activities continue to have an above average publication record. In other words, interactions between spin-offs and parent institutes are and will remain heavily personalised as the following mechanism applies: sustained interaction between both parties presupposes personal continuity, and only tenured academics are in a position to ensure personal continuity. This overall trend has different implications. On the one hand, public research organisations relating to the biotech sector will continue undergoing massive change in order to meet the demands of a few persons doing science-industry (as managing intellectual property requires centralisation). On the other hand, in the areas of IT, doing science-industry is also personalised but will continue to be a much more decentralised phenomenon (due to lower capital needs and shorter time to market). While this is not a dark scenario, policy makers should prepare for an alternative one. De-personalising the science-industry interface presupposes that research groups (that stay at the research institute and accompany the creation of spin-off companies) are provided incentives, either money or reputation – or both.

1. INTRODUCTION

Re-conceptualising science-industry relations is a demanding task. On the one hand, despite many criticisms, the "linear model" is still alive (Grandin et al. 2004). On the other hand, a number of alternative approaches have been presented. Broadly speaking, their common interest is to promote an "interactive model" (MacKenzie 2004). Investigating interactions between academic spin-offs and their parent institute, the PROKNOW research project has decided to take the "interactive model" of science-industry relations seriously.

Paradoxical as it may seem, as a matter of political concern, there is no need to take the "interactive model" still more seriously. Among the proponents of the "interactive model", many claim that one cannot wait for industrial applications to be generated "by implication" of scientific knowledge. Instead, it is claimed that points of contact and levels of interaction have to be fostered in order to overcome their current marginalisation and lack of recognition. In this view, it follows that doing science-industry has to be rethought of as an activity in its own right. According to the European Commission, for instance, it is an urgent task to install more efficient (read: more interactive) mechanisms of transferring knowledge from science to industry. If Europe fails to do so, it would inevitably be confronted with the dark side of global competition (Felt & Wynne 2007). Hence, the "interactive model" has quickly been associated with high political expectations. Its success has overtaken empirical research in this area. In our view, the challenge of properly analysing science-industry relations has not been met. As a consequence, the task of understanding the production and consumption of knowledge across public and private spheres (as stated in the goals of the Sixth Framework Programme for Research and Technological Development), is still waiting to be brought to empirical analysis.³

The present document reports on a research project which has taken a few steps in this direction. Its focus is on academic spin-offs⁴ and their parent insti-

³ For an attempt to evaluate the tightened European agenda in matters of innovation policy, see European Commission, Directorate-General for Research (2008).

⁴ For a definition, please refer to the first sentence of the executive summary. Within the PROKNOW sample, some countries do not have non-university public research organisations. In some of these countries (especially the UK), it is therefore more common to use the term "university spin-off" (USO) instead of "academic spin-off". Choosing the term "academic spin-

tutes, and its aim is to take a shift in perspective: If there is science-based industry, how about entrepreneurship-based science? What is the impact of academic spin-offs on their parent institutes?

a) Outline of the report

As stated earlier, the field we have entered enjoys high political expectations, and this situation has affected our research in important ways. First, we found ourselves to be part of a crowd of researchers trying to get in touch with a small population of academic entrepreneurs and entrepreneurial academics. In a field which is highly fragmented and therefore challenging to be investigated by means of quantitative analysis, we have sometimes participated in a race for interviewees. On the other hand, we have frequently faced interviewees who had specific expectations on our focus of research. These are practical issues and problems encountered while trying to overcome the linear model and to adopt a perspective closer to the interactive model. Following the exposition of our strategy of sampling and casing, the second part of chapter 2 reflects on some of these issues. In the first half, we explain why we use a rather supple definition of academic spin-offs, and why we have chosen to work on clusters consisting of five spin-off companies and a parent institute. This sampling procedure follows a "topographical" approach which is then presented as a combination of two more familiar approaches, exploring either network ties or relations of proximity. Having decided to study only top concentrations of spin-off activities, we are left with a small number of case studies, namely in the areas of IT, biotechnology and nanotechnology. The units of analysis underlying our case studies are far from being "natural entities". Introducing them as "IT Land",

off" is a compromise for at least two more reasons. First, it rests on a highly inclusive notion on what counts as an *academic* institution. For instance, should Universities for Applied Sciences be considered "academic"? Some PROKNOW partners have included this type of organisation in their sample. Insisting on the fact that, in the Netherlands, the term "academic" is used in a more exclusive way, the Dutch PROKNOW team has preferred to speak of "Research-based spin-offs" (RBSO) in their individual publications (Zomer et al. under review). While the aforementioned reservations may be labelling issues, the Bulgarian PROKNOW team has radically questioned the concept of "academic spin-off". Pointing to the recent history of the public research sector, it would be erroneous to think of "academic spin-offs" in terms of a settled cognitive and political category. By consequence, the Bulgarian PROKNOW team has adopted a genealogical approach to study the shifting uses of a term which is still far from established (Tchalakov et al. under review).

"BioLand" and "NanoLand" we intend to indicate our efforts of constructing case studies.

Lands are made up of more or less continuous interactions observed between academic spin-offs and their parent institutes. Chapter 3 presents the results of our inquiries related to the three lands explored. Departing from the usual approaches which tend to observe interactions either at the level of individual researchers or at the level of entire research organisations, departments or universities, we have decided to focus on interactions between academic spin-off companies and research groups. With regard to this particular level, our inquiry has shed light on agenda overlaps, on the generation of novel contacts in science and industry, and on the role of intermediaries such as technology transfer units fostering or buffering interactions.

Having set the stage through the previous steps of analysis on "lands" and "interactions" chapter 4 reports on the repercussions of spin-off activities on their institutes of origin. Relating repercussions to the black box models of scientific production, namely the input and the output model, our findings remain scattered and sometimes of little surprise. In turn, our most striking finding is about the internal organisation of research institutes. Contrasting a wide-spread interpretation, we cannot confirm that research institutes engaging in spin-off activities, be it for the purpose of patent portfolio management, would inevitably end up as more centralised and corporate-like organisations. Rather, we claim that another aspect of repercussion is more relevant. To borrow a term frequently used by participants, we have found a (male) professor-centric pattern of the way academic spin-offs relate to their parent institutes. This finding leads us to reconsider spin-off processes in terms of domestic relations. To a considerable extent, doing science-industry depends on a single person (enjoying the degrees of freedom of a professorship). Whether this finding may be taken to confirm the "interactive model" is a puzzling question.

Chapter 4 also includes a number of caveats which help to better understand our research model. What kinds of "repercussions" are we likely to capture by using the described path of inquiry? For instance, we are not in a position to observe changing dispositions of individual scientists. Another caveat is due to the absence of control groups. As a consequence, we were unable to apply a straightforward mode of hypotheses testing. For instance, our research design

does not support general claims on whether academic spin-offs are bad for science.

To anticipate on the conclusions (chapter 5), we have to recall that we deliberately skipped the usual format of case studies based on national perspectives and their respective systems of innovation. We also refrained from limiting our analyses to a certain type of research organisation at the outset. On the basis of these caveats, our conclusions will not be ready for application at the level of national systems of science and innovation. Having circumvented aspects of the institutional layout, we carefully generalise from our case studies. For instance, while we have not found academic spin-offs deteriorating the quality of scientific work, we cannot conclude that there are no bad repercussions.⁵ On the other hand, while spin-offs can have a multitude of positive side-effects for parenting research institutes, it turns out difficult to provide a recipe enumerating conditions for good repercussions. If there is a concrete way to incentivise transfer activities, it consists in rewarding those who stay at research groups which have accompanied the creation of spin-off companies. This is what we call the "immediate context of origin" of an academic spin-off.

Policy learning may benefit from a number of concluding reflections. First, we comment on why "academic entrepreneurialism" has gained levels of attention which seem clearly disproportionate with regard to its real-life dimensions. We then again contrast these "spectres haunting Europe" with our mundane attempt to construct case studies.

To begin with, we will now turn to a few threads of literature most relevant to developing our research question. Among other things, we will discuss claims that, in recent times, interaction between science and industry has intensified and forms of interaction diversified. We will comment on efforts to capture industrial research as an object of research and evaluation. And we will delve into work that is critical of the commercialisation of science. Covering a great variety of research, we will show that most of the literature reviewed continues to subscribe to the linear model.

⁵ To state it more prosaically, there can be "bad repercussions" without "interactions" as discontents of commercialisation (see earlier section) would say. On the other hand, we cannot claim to have brought a micro-foundation to their critical claims.

b) Entrepreneurship-based science?

Despite their emphasis on "scientific practices", and despite their conviction that these practices are by no means bound to the walls of public research organisations, science studies have devoted little attention to academic spin-offs. A few solidly made and well written single case studies (Rabinow 1997; Tuunainen 2005) can hardly compensate for the lack of thorough comparative analysis based on qualitative methods. Although based on long-term research on academic spin-offs, a recent publication on "Academic entrepreneurship in Europe" (Wright et al. 2007) does not close the gap either. It is primarily written from a public policy perspective, and it seeks to enlighten a public policy perspective which seems to have been too focused on a single type of academic spin-offs and hence ignored the heterogeneity the phenomenon has taken. The authors suggest that this is a finding in itself: Academic spin-offs in Europe take various forms and roles whereas the US counterpart is depicted as following some sort of standard model. This is said to reflect the different institutional layouts of research and higher education systems across European countries. On the other hand, research on companies spun off from US universities has repeatedly asserted that spin-off activities are far from evenly distributed. Instead, there are some points of high concentration which leaves a puzzling question as to what causes different rates of spin-off activities. In a pioneering work, Henry Etzkowitz (2000) has related the development of MIT to the emergence of entrepreneurial ways of doing science. Maryann Feldman and Pierre Desrochers (2004) have presented a somehow contrasting study on Johns Hopkins University, Baltimore: This particular university, despite a favourable economic context, did not come up with a remarkable level of entrepreneurial activity. How then to account for this variety? Focusing on delicate patenting issues, Jason Owen-Smith (2006) has tried to do justice to an ambivalence found in the relation of academic spin-offs and their parenting universities. As we are particularly interested in the ways academic spin-offs and their parent institutes co-evolve, our research design has focused on top concentrations of academic spin-offs at universities and public research institutes in seven European countries. While we do not take the MIT case as documented by Etzkowitz as a model, we follow his approach in that we are no longer preoccupied with determining conditions of the conditions of survival of academic spin-offs but rather try to explore reverse impacts.

How best to characterise science being based on entrepreneurship? As mentioned above, previous studies have tried to determine the impact of entrepreneurial activities at the aggregated level of entire universities. But what about the laboratory level which has long since been discovered to be the productive unit of research? In accordance with ethnographic studies of laboratory work (Knorr Cetina 1981; Latour & Woolgar 1986 (1979)), we find it appropriate to highlight the level of research groups. This choice is also justified by the selection of disciplines and research areas for our study. While in the humanities and in some areas of the social sciences the research group or laboratory level might be irrelevant, it is a trademark for the areas of research and innovation which have shown closer affinities to entrepreneurial activities.⁶

c) Has interaction between science and industry become more intensive?

Concerned about increasing policy pressure to make science more useful for industry, Pavitt (2004) distinguishes between more "direct" and more "roundabout" versions of technology transfer. In his view, this distinction is firmly inscribed into sectoral logics. Therefore, there can be no political strategy to turn areas marked by "roundabouts" into areas of direct transfer. We agree with this conclusion. Interestingly though, Pavitt quotes research training to illustrate the roundabout model; although the direct model is said to be epitomised by academic spin-offs (ibid.). Transfer via academic-spin-offs is often thought of as being the direct link from science to industry. This is why it has contributed to rescue the linear model at a moment in time when it was threatened to be abandoned. To state it more drastically, academic spin-offs and the ways they relate to the academic world have been welcomed by the proponents of the linear model. As a result, academic spin-offs, in terms of an object of policy and research, have been dominated by the linear model. The promise of "direct" transfer, without uncertain and costly loops and "roundabouts" has encouraged generalisations that are now known to have been too hasty. Neither have academic spin-offs flourished in all areas of research and innovation equally well,

⁶ By taking the research group as the centre of our attention, we try to get as close as possible to the "research collectives" and the dynamic understanding Callon (2003) has given to this term. As compared to the organisational or institute level and the individual level, it is the intermediate level of research groups which is most likely exposed to change and to initiate change.

nor has their number been significant enough to justify hopes of a shift towards "direct" transfer.⁷

Having agreed with Pavitt's reservation that more "roundabouts" are inscribed into sectoral patterns and will therefore persist, we question his use of academic spin-offs taken as an example for the straightforward and supposedly linear model of transfer. Turning to the fields where most academic spin-offs have been counted, we suggest not taking them as candidates that would entirely fit the linear model, but rather as a collection of candidates that, to different degrees, are more appropriately understood if using an interactive model. Also, this move is necessary to prepare for a second one: Specifying and capturing ways of interaction is a prerequisite to ascertain the consequences of spin-off activities for research institutes. (If there was no interaction, one would suppose that transfer activities would not impact on parent institutes.)

Leaving aside the particular case of academic spin-offs, the assumption that interactions between science and industry have become more intensive is far from being marginal in the relevant literature. Also, it appears to be undisputed that forms of interaction have diversified (Schmoch 2003; Mustar 2003a, b). However, when it comes to specifying and interpreting these claims, there is a lot of controversy. Interaction may have increased and diversified, but what is the driving force behind this development? It may not be surprising that this question is no longer a matter of consensus. Broadly, we may distinguish three positions. Either the proliferation of interaction is brought down to shifts in the underlying economic structure. Proponents of this position argue in terms of "regime changes" (Mirowski 2008; cf. Kleinman & Vallas 2001). Levels and types of interaction are related to specific regimes. By implication, they challenge the idea of a continuous growth of interactions through different regimes. A second, less outspoken position gives public policy the position of a prime mover. Do higher levels of interaction result from changes in public policy (Zomer et al. under review)? This argument is often accompanied by a second one: While there have undeniably been important changes in science and innovation policy, why should they result in changes which just reflect the goals of these policy actions? The present report is closer to a third position: Why take it for granted that increasing levels of interaction result from external changes, be it the economic structure or public policy or both? Rising levels of interaction are

⁷ See Callan (2001) for a similar estimation and for figures on high-tech spin-offs in Europe.

to be primarily regarded as a byproduct of an internal dynamics characteristic for certain areas of research and innovation. To sum up, as soon as one starts investigating the causes for increasing levels of interaction, one ends up in a dispute between "materialist" and "cognitivist" explanations or, between "externalist" and "internalist" accounts.

Adopting the third position, we will not be able to determine exactly when, and due to what causes, interactions between science and industry have become more intensive. Based on the current state of discussion it appeared more appropriate to narrow down the focus of analysis on one single type of interaction. This is partly for the sake of selectivity, and partly due to our aim to study a linkage which was too prematurely dubbed to be the renaissance of a direct and linear form of transfer.

Interactions between academic spin-offs and their parent institutes have only recently become a subject of inquiry (see Konrad et al. under review). It is (partly) privately funded research centres which have raised higher expectations in terms of "interactions". Nathan Rosenberg notes that research centres "have managed to create close interactions, and exchanges of information, between those responsible for performing the research, on the one hand, and those responsible for the management of production and marketing, on the other" (Rosenberg 1994: 506). To anticipate on the PROKNOW sample of case studies, some of them are actually embedded in "research centres". However, contrasting the US cases (Rosenberg refers to), these research centres are not sponsored by industry. It is important to clarify that industry – in the sense of large industry – is absent from our research design. It does not appear on stage, neither as a sponsor nor as a partner of interaction. We extend the use of the term "industry" beyond large industry associated with large-scale processes of production and the type of engineering knowledge that is required to run and control these processes. In our view, research has focused so much on large industry and the way it interfaces with (big) science (Rosenberg 2003 provides further illustration) that it has neglected ways of "doing industry" going on at less spectacular and much smaller interfaces. This is not to exclude, however, that the clusters we look at might end up being joined or partly financed (or eaten up, as some would say) by large industry. In a few cases, spin-off activities have been a detour and a door opener for more large-scale collaborations between science and (large) industry.

d) *Industrial research as an object of research*

Since the seminal papers by Kenneth Arrow and Richard Nelson it has often been repeated that private firms failed to invest in science because there was no incentive for engaging in knowledge production. Among others, Nathan Rosenberg (1990) states that knowledge production within private companies is unlikely unless investments in knowledge are appropriable. If one looks at research carried out by private firms from this perspective, the object of analysis is fairly confined. Do firms do basic research? – Answer: Yes, a few firms are conducting basic research, within a few sectors (ibid.). These firms are usually easy to identify. They are large and well established firms enjoying market power, and they engage in patenting activities (ibid.). According to Rosenberg, only these firms can afford to invest in "basic research". While the number and scope of basic research activities carried out by these companies may have declined since the article was published, its major argument is still worth considering. It states that companies need basic research capabilities in order to take informed decisions on (larger) investments in applied research. "[A] basic research capability is often indispensable in order to monitor and to evaluate research being conducted elsewhere" (Rosenberg 1990: 171). Basic research then figures as long-term investment which helps companies to stay in contact with the scientific environment. The author also claims that the level of consciousness about these basic research activities is low. Whatever company does basic research does not do so in the name of basic research. No one would ever sit down and ask: "Should we do basic research?" Instead, basic research in industrial contexts is usually depicted as an "unplanned by-product of the attempt to solve some very specific industrial problem" (Rosenberg 1990: 169).

With regard to the first point raised by Rosenberg, it follows that basic research activities carried out by private actors should be subjected to careful if not conservative scrutiny. There is a constant risk of overestimating the contribution of private companies to basic research. His second point, however, leaves us less convinced. Yes, the level of consciousness of those doing science within industrial contexts may be low, but what follows from his claim that basic research in industrial contexts necessarily features as an unplanned by-product of activities which are undertaken to achieve non-research aims? Rosenberg is right to in-

sist that the distinction between basic research and applied research cannot be detected at the level of individual researchers and their motives. But why should this be different in academic contexts? Basic research normally takes place in universities and dedicated public research centres. But if private companies happen to do basic research, do they do so by accident? In other words, we suspect his account to be built on a presupposed asymmetry. We therefore suggest taking another look at the question of whether private companies are doing science and extending that inquiry to academic spin-offs without an a priori distinction of what private companies and public research groups normally do. This has lead us to contribute to the recent line of inquiry on intersystemic organisations, that is organisations which are simultaneously bound to more than one social field or social sub-system (Potthast & Guggenheim 2008, cf. Guggenheim 2005).

Research on industrial research has often struggled to properly capture its object of investigation. It is somehow left in a blind spot despite major research efforts (Hack & Hack 1985) and despite the fact that expenses in support of industrial research are now routinely processed by national and international statistics.⁸ Being aware of these difficulties, we use a double strategy to generate new knowledge about industrial research. First, we extend the inquiry to academic spin-offs, i.e. to small and nascent companies. Second, with regard to the methodological questions just mentioned, we claim to deliver a more reliable picture as our explorations on how academic spin-offs interact with their parent institutes systematically draw on perspectives of both parties involved. This is precisely how we intend to avoid over-representing industrial research and its more recent counterpart: The display of being useful to industry as delivered by many research institutes throughout all countries represented in the PROKNOW consortium.

e) Commercialisation of science and its discontents

Derek Bok, a former president of Harvard University, is among the more recent and prominent voices to criticise the ways public research institutes and universities have responded to the opportunities of commercialisation. Without going into details, his account of the repercussions of old and new forms of science-industry interactions is sobering. Bok (2003) states that commercialisation af-

⁸ Note that these figures rely on estimates provided by the companies themselves.

fects research institutions simultaneously at a variety of levels, among them the behaviour of individual scientists, relations between faculty members (cf. Owen-Smith & Powell 2002; Rappert et al. 1999), relations between departments more and less actively involved in commercialisation and, finally the public representation (and reputation) of science (cf. Croissant & Restivo 2001). He is clearly most concerned about the last aspect, stating that "the university's reputation for scholarly integrity could well be the most costly casualty of all" (Bok 2003: 116). Following his account, the benefits of commercialisation are often overestimated because they are more tangible than risks: "Commercialization typically begins when someone in the university finds an opportunity to make money: an offer of generous research funding in exchange for exclusive patent licensing rights; a chance to sell distance courses for a profit; or a lucrative contract with an apparel manufacturer offering cash and free athletic uniforms in return for having players display the corporate logo" (ibid. 99). On the other hand, erosion is a more silent process. He finds costs associated with commercialisation activities difficult to assess. Due to a weakness of current methods of evaluation, they may even be said to remain entirely invisible: The more attention that is given to rankings and ratings, the higher the pressure becomes to compete for a majority of universities and departments with a minority of entrepreneurial universities and entrepreneurial disciplines.

Next to this devastating critique of institutional blindness (or institutional erosion) a number of more familiar observations on the costs of commercialisation appear on his list; barriers to the open circulation of knowledge due to restriction imposed by industrial collaborations, conflicts between faculty and administration, loss of trust among colleagues. Bok also sets out to counter the major arguments raised to support moves toward commercialisation. While commercialisation is often seen as a means for universities to climb up in the rankings and for individual researchers to improve their status, he warns that none of these hopes is justified. Neither have universities climbed up the ladder by increasing the scale and scope of their commercial activities,⁹ nor has commercialisation helped to neutralise the various imbalances of power and domination within the academic system (ibid. 114).

Publications that deal more specifically with academic entrepreneurship report similar problems resulting from creating and interfacing with academic spin-offs

⁹ Stanford University remains a, however disputed, exception to that rule (cf. Lowen 1997)

(Shane 2004: 277-292; cf. Franzoni & Lissoni 2006; Lowe & Gonzalez-Brambila 2007). "Problems with academic spin-offs" are either related to the efforts of integrating a mission to spin-off into the traditional model of the university or to "problems of earning financial returns from technology licensing to spin-off companies" (Shane 2004: 277). In addition to the critical points raised by Bok, Scott Shane underlines the following tensions. First, due to the governance form of universities, faculties must in their majority support policies and procedures favourable to spin-off creation. Faculty responses to commercialisation may differ from the position of the central administration generally supportive of spin-off activities. Second, there is a problem which relates to the success/failure of a spin-off: "Living dead firms, unable to commercialize a piece of technology, but holding an exclusive license, these firms keep others from using technology" (ibid. 282). Third, conflicts of interest may arise if researchers have a choice to raise money for a company or to conduct a research project. Fourth, a number of problems are related to patenting. The costs of developing a spin-off are high, if they require assistance in "negotiating agreements and defending their patents in lawsuits" (ibid. 287; cf. MacKenzie et al. 1990; Mowery et al. 2004; David & Hall 2006; Geuna & Nesta 2006)). How much risk can a university take? Can it allow itself to be tied to the fate of a spin-off and lose important amounts of (tax-payers) money? In addition to the financial loss, the universities' reputations may suffer if they are identified with the founders' failure or misbehaviour (Shane 2004: 289).

We do not claim that these lists reporting on potentially detrimental impacts of commercialisation will be further elaborated and clarified by studying interactions between academic spin-offs and their parent institutes. The issue is not merely whether or not spin-off activities can be detrimental to science, but also in what respect. Also, collecting information on interactions, our scope of observation is limited. Therefore, we will not contribute to the discussion that focuses on the erosion of trust at a more structural level (Bok 2003). Unlike some authors who, under the headline of a "new economy of science" (Dasgupta & David 1994) have returned to a Mertonian sociology of science, we will not speculate about the troubling effects of market forces threatening distinctive features of knowledge production. However, staying closer to micro- and meso-level observations, we are not obliged to join the pro-camp either.¹⁰ The issue is

¹⁰ For instance, we do not keep asking a naive question typical of the pro-camp: "Why would it be bad or controversial to commercialise technology that otherwise would be undeveloped?"

whether it is possible to determine more specific circumstances under which creating and interacting with spin-off companies may involve conflicts of interests or turn evil (see Konrad et al. under review).

"Everyone knows that the linear model of innovation is dead" (Rosenberg 1994: 139). By consequence, there is no need to bury it once more. Nevertheless, the four preceding sections have discussed streams of literature which have provided various sites for the reemergence of the linear model. Trying to build an alternative model called the "interactive model" and to bring it to empirical inquiry, we have therefore, once more, encountered the enormous flexibility of the linear model and its key distinction that opposes basic science and applied science. While most authors quoted in the previous sections would argue that the interactive model applies to a few islands within a large sea governed by the linear model (Pavitt says that only a few scientific fields linking up "directly" with a small number of industrial sectors escape the old model; Rosenberg says that only some large companies are capable of doing basic research – with regard to any other phenomenon, institutional boundaries separating basic research from applied research can be taken for granted), we have opted for a case that some find epitomises the linear model (or its renaissance): academic spin-offs and the way they relate to their parent institutes.

2. LANDS

As stated before, the current chapter retraces our strategy of sampling and casing. To begin with, we explain why we use a rather simple definition of academic spin-offs and why we have chosen to work on clusters consisting of five spin-off companies and a parent institute. This sampling procedure follows a "topographical" approach which is then presented as a combination of two more familiar approaches, exploring either network ties (Powell et al. 1996) or relations of proximity (Audretsch & Stephan 1996). Having decided to study only top concentrations of spin-off activities, we are left with a small number of case studies – and a small number of sectors and disciplines. Reflecting both the distribution of spin-off activities (and the attention of fellow researchers) we concentrate on the areas of IT, biotechnology and nanotechnology. The units of analysis underlying our case studies are far from being "natural entities". Introducing them as "IT Land", "BioLand" and "NanoLand" we intend to indicate our efforts of constructing case studies. Although we sometimes make use of the notion of "cluster", we prefer to use the less technical term of "lands" to label our case studies. Subsequent analyses will try to map these lands in order to better understand both the commonalities and differences. Choosing the notion of land instead of the more technical term of "cluster", we emphasise relations of proximity. The clusters we have identified are local phenomena. On the other hand, "land" should not be understood in a territorial sense. We have often encountered a striking sense of belonging to a land, but there are no fixed boundaries. On the contrary, most of the lands under study are rather dynamic entities.

a) IT Land, BioLand, NanoLand: Exploring high concentrations of academic spin-offs

Defining and classifying different sorts of academic spin-offs is a demanding task in itself. The same applies to their parent institutes. In order to identify "cases", we have looked for clusters consisting of five academic spin-offs and their parent institute. While there was no further restriction on the choice of parent institutes (but an invitation to go for the highest possible variation), we have only considered "successful" spin-off companies which should have operated for more than three years and are of a minimum size of five persons. In addition, we tried to identify the lab or sub-unit the spin-off companies have

emerged from.¹¹ To borrow on the classification by Clarysse et al. (2005), clusters or lands may cover up to three distinct types of companies:

(a) A first type of company is associated with the idea of "self-employment". It does not imply a transfer of intellectual property and only requires a small capital base. Many of these companies have been excluded by the criterion on firm size.¹²

(b) A second type of company is more oriented towards the commercialisation of technology. It requires a higher amount of capital and personnel as the first type. It is generally regionally embedded - both with regard to industry and the public research sector. It is this type of company we most frequently encountered throughout all areas of research and innovation.

(c) A third type of company is devoted to the development of highly specialised products and therefore addresses global markets. These companies require venture capital. Their creation is sometimes motivated by an exit capitalist strategy. Our sample includes a few of these companies, all of which prepare biopharmaceutical products.

While the aforementioned criteria have guided the construction of any single case study, a further guideline has been used to compose a "national sample". Each of these samples was expected to consist of at least three case studies covering different areas of research and innovation, namely IT, biotechnology, and nanotechnology. To varying degrees, partners have included more case studies serving diverse purposes of intranational comparison. As a result, the PROKNOW consortium has worked on 35 case studies, 13 of them covering IT, 12 covering biotechnology, and 10 covering nanotechnology.

The PROKNOW research teams have used different strategies to select case studies and to build up a sample. First, they usually referred to annual reports of research institutes, company websites, and other material available via internet. Some have turned towards existing databases or case studies available by re-

¹¹ Note that the size of "parent units" or "sub-units" varies between case studies. Some PROKNOW teams have opted for small sub-units and accepted less than 5 spin-offs; some have given priority to the minimum number of spin-offs and selected a larger parent unit.

¹² The decision to exclude very small companies was based on a rather formal assumption and informed by the literature on inter-organisational networks which states that partners are most likely to interact if they are of similar size (Sydow 1998). Also, we do not expect micro-companies to have a measurable impact on large research organisations.

search or other publications. In many cases, phone calls were necessary to complete the process of selection. At this stage of research, technology transfer offices at various research institutions have assisted PROKNOW teams. They would know best whether there are five spin-off companies and whom to approach for interview requests. By and large, all PROKNOW partners have been successful in identifying case studies that match the selection criteria agreed upon. In a sense, the casing criteria have been confirmed as they have been found highly selective. In all countries and across the three areas of research and innovation, they have helped to identify top concentrations of spin-offs.¹³ This was the main intention that motivated our set of selection criteria. On the one hand, we expected spin-off activities to have an impact on research organisations where they reach their highest concentration; on the other hand, we expected these top clusters to be laboratories of interactions (between academic spin-offs and their parent institutes) both in terms of their density and their variety.

b) Barriers

Having identified case studies, we were prepared to take the second step of analysis. Approaching the lands and trying to describe them in terms of the interactive model, we encountered some practical problems. As stated earlier, some of them are related to heavy political expectations weighing upon our subject of inquiry. On the one hand, PROKNOW teams found themselves to be part of a crowd of researchers (and business press people) trying to get in touch with a small population of academic entrepreneurs and entrepreneurial academics. On the other hand, many interviewees had specific expectations on our focus of research. The current section reports on how we dealt with these issues, and provides an overview of the quantity and quality of the data collected.

The main sources for empirical analyses are semi-structured expert interviews with CEOs of spin-off firms and representatives for the institute of origin who have been involved in the spin-off process. In total, some 250 interviews were carried out, about 100 conducted with spin-offs and 150 with parent institutes. In most cases, both spin-off company founders and their corresponding parent

¹³ Some PROKNOW research teams have quantified this concentration by providing a ratio of "spin-off creations per fulltime equivalent research position". The claim to have studied "top concentrations" rests on absolute figures.

and partner institute's colleagues (including researchers, administrative directors and technology transfer staff) were interviewed. Interviews thus covered two perspectives on processes of interaction and a variety of sectors (IT, biotechnology, and nanotechnology) in each country.

Similar numbers of interview requests were turned down. While this rate of refusal may not be unusual for expert populations, a few reflections on the process of successfully arranging interviews will serve introductory purposes.

CEOs of spin-offs receive a lot of interview requests and have to decline most of them. This is why we tried to approach them with a reference which would be familiar to them: Most case studies were arranged with some assistance from technology transfer staff based at universities and research centres that was always ready to respond. More so, technology transfer people often played a crucial role in matching "tandems" of companies and their parent research unit. In some cases, they actively filtered and selected our lists of interview requests and continued keeping an eye on us and/or showing interest in whom else we were going to talk to and if progress was being made. Some technology transfer people underlined that they had to protect a precious population against an overload of external requests. Apparently, taking care of the "entrepreneurially minded" has become part of their job description. In addition to technology transfer people, we sometimes enjoyed the support of heads of institutes to approach another group within our research population that was most unlikely to participate: researchers who had accompanied spin-off processes. While this sub-population has not been sought after by fellow researchers (or mass media), they frequently felt uncomfortable to be identified by a role they usually do not consider central to their professional life.

Having mentioned a few obstacles, why should interviewees who, for different reasons, tend to decline interview requests, accept to be interviewed by PROKNOW teams? At least some said that they were convinced by the idea of inverting the common research question; that is to ask for the consequences for parent organisations instead of looking for conditions of survival. On the other hand, as the purpose of the project was not self-evident, interviewees needed to be introduced to it. By implication, the research process, although based on interviews (and a few second or feedback interviews) can be described as interactive. Interviewees developed their own idea of the research project and its

purpose. Some contested the research question; some were highly sceptical about its being researchable; some challenged the research design as an appropriate way to generate reliable results; some acclaimed it as being innovative.¹⁴

Having successfully entered the field and having carried out some 250 interviews is no guarantee for reaching unexpected and counter-intuitive insights and new knowledge. A major challenge encountered during the interviews consisted in avoiding the distinction of basic vs. applied research. Most interviewees were eager to reinvent this distinction which has certainly proved useful for science policy negotiations but no longer has any analytical quality (Calvert 2006). Hence, a number of methodological provisions have been taken to avoid generating empirical material that is overly structured by mere strategic uses of this distinction. To the extent possible, we have borrowed on a strategy successfully practiced by the science studies literature which consists in exploring the situated and material activity of scientific research.

Having pointed to the modalities of identifying cases and approaching interviewees, it is now clear that our study is far from being based on "natural cases". The "lands" we decided to enter did not resemble circumscribed areas which would be internally structured and provide for clear-cut role definitions and other categories. In this sense, PROKNOW has also deconstructed pre-established ways of thinking about academic spin-offs and their parent institutes (more in line with the linear model). To state once more, we did not approach parent institutes in order to study policies and institutional frameworks which would help explain distributions of spin-off activities across institutions, across regions, or across sectors.

¹⁴ A few more words regarding the technology transfer people. They have been facing a situation which was similar to ours. When they arrived at their job, there was no list of academic spin-offs and of "representatives of the institute of origin who have been closely involved in the spin-off process" because these categories were not yet established and continue to be rather soft categories. The latter category is particularly demanding, and its formulation remains awkward. If it has been a workable definition for the PROKNOW project, this is because of the research process leaving enough time and space to achieve a shared understanding. The term itself and the research procedure are far from being ready for use in larger quantitative studies.

3. INTERACTIONS

As explained in the previous chapter, lands are made up of more or less continuous interactions observed between academic spin-offs and their parent institutes. The current chapter presents the results of our inquiries related to the three lands explored. Departing from the usual approaches which tend to observe interactions either at the level of individual researchers or at the level of entire research organisations, departments or universities, our focus is on interactions between academic spin-off companies and research groups. With regard to this particular level, our inquiry has shed light on agenda overlaps and on the generation of novel contacts in science and industry. Finally, we re-interpret the role of intermediaries such as technology transfer units as fostering or buffering these interactions.

The literature on science-industry relations has a predilection for large interfaces. Sometimes, thinking big and watching huge "platforms" goes at the expense of providing an understanding of the more everyday practices and processes of science-industry linkages. At its extreme, the literature can no longer be distinguished from press releases provided by the collaborative research centres and platforms and their sponsors.¹⁵ Of course, there are scholars who are interested in the "factual interaction" (Schmoch 2003: 207). Apparently though, they are condemned to present open-ended lists of any point or countable item of interaction one could think of. For example, knowing about "phone calls" received by industrial collaborators provides too little insight into the actual process of interaction. In the following, we sketch an alternative way somewhere between the two alternatives of either name-dropping (although a number of "famous" collaborations figure among our case studies) or listing (although establishing indicators and formatting lists was an important intermediary step of analysis).

As announced, our analysis will highlight three aspects of interaction: First, we try to find out more about the nature of interaction. To what extent are they dependent on persons? What is their level of professionalisation? How does the degree of personalisation relate to the degree of professionalisation? Second, we seek to determine to what extent interaction is exclusive. Do parties involved

¹⁵ For illustration, see Riehemann et al. 2007.

in interaction end up in some sort of exclusive partnership? Or do interactions have catalyst qualities which extend rather than restrict the number of contacts and collaborations? Admittedly, our sampling strategy has already taken a decision to investigate non-exclusive pairs (one parent institute or sub-unit and five spin-off firms). However, as we are primarily interested in parent institutes' research groups and take these as a point of reference, we further ask if these contacts extend more toward the business world or toward the academic world. Admittedly though, we cannot trace new contacts in a way that would satisfy the standards of quantitative network analysis. A third bundle of questions is directed at the contents of interaction which cannot be deduced neither from its nature (more or less personalised; more or less professionalised) nor from its being more or less exclusive (or attracting more partners of interaction). We are particularly interested in finding out whether interactions develop within a pre-defined value chain or involve more complex forms of coordination. The former would be in tune with assumptions supported by the linear model (leave basic research tasks to the research institute and later stages of development to the company). The latter would provide evidence to the interactive model.

Our presentation proceeds the other way round, starting with some condensed observations on the contents of interaction.

a) Complex coordination

According to a frequent observation, it is the co-founding professor who most clearly has a chance to stay in both worlds. Some professors do so permanently but they happen to be in a minority. Most professors interviewed are happy to report on a one-off experience with spin-off activities and the insights drawn from a single "market test". This may have initiated catalyst dynamics as discussed in the following section. But in the first place, to be involved in a spin-off is framed as a key experience in their professional life by many academic partners of academic spin-offs. For many interviewees this also provided an unexpected yet agreeable side-effect. A professor who has been involved in a successful venture is given higher credits in both the academic and the business world. In other words, academic partners of academic spin-offs enjoy a competitive advantage (over their academic colleagues). We argue that this advantage is sometimes reinvested and leads to what we call constellations of "complex

coordination".¹⁶ In these cases, interaction transcends a one-way sequential pattern which would allow both spin-offs and their parent institutes to look like fully separate entities doing fundamentally different things. In such cases, repercussions on scientific activity are more likely to be observed. If the creation of an academic spin-off is not followed by processes of complex coordination, repercussions will be a higher individual reputation (and its more indirect effects).

In order to qualify as "complex coordination", interactions have to extend in time. Also, its terms are not fixed in advance but are subject to a continuous redefinition. For certain, when it comes to the question whether complex coordination may result in changes of research behaviour (see next chapter), more long-term studies based on ethnographic observations are desirable. The present analysis rests on a more modest approach. Being based on semi-structured interviews, it has to compensate for temporally extended observations by other means.

Joint research projects are the most visible indicator of complex processes of coordination between academic spin-offs and their parent institutes. Yet, if co-projects do not relate to or entail other forms of interaction, they may remain confined to areas and topics initiated and shaped by governmental funding schemes. This observation recurs in a number of sub-cases. If exclusively channelled by the requirements of collaborative research projects, the level of repercussions to be expected from co-projects is low. Therefore, we can speak of "complex coordination" only if joint projects trigger other forms of interaction. For instance, joint projects may coincide or intertwine with a transfer of staff. The recruitment process of knowledge-intensive firms' employees is not a one-off market transaction. Rather, it involves a long process of testing and trying where new personnel must be "socialised" into the firm. If we consider flows or exchanges in terms of personnel as a second indication for "complex coordination", this is because new personnel often choose to accept a small income and simultaneously try to pursue the path of scientific qualification. To return to and

¹⁶ The notion of "complex coordination" is introduced for exploratory purposes. In lieu of a succinct definition, we suggest to refer to an analogy, namely the understanding of "flexible specialisation" in the literature on industrial production (Piore & Sabel 1984). As opposed to Taylorist model where interaction is governed by an agenda fixed in advance by scientific means, flexible specialisation (and "complex coordination") involves local re-adjustments of agendas.

simplify our argument: if interaction is limited to either a joint project or a single transfer of staff, there is no complex coordination. If these instances of interaction multiply, there is. Complex coordination allows for multiple feed-back loops which are characteristic for high levels of knowledge absorption (Cohen & Levinthal 1990). These processes may result in multiple outcomes which are directed both towards academic research and industrial application. However, as stated earlier, only a small fraction of our sample illustrates this kind of evolution. For instance, we have rarely found collaborations between academic spin-offs and their parent institutes to result both in joint publications and jointly developed products. On the other hand, there are many examples which just confirm the linear model idea of an interface which allows for one-way transactions of previously defined and pre-packaged components.

From a research institute's perspective there may be no difference whether to interact with small academic spin-offs or with large companies. In turn, at the level of research groups, we often encounter a different view. Interviewees often prefer the "smaller" interface. According to them, it is often more satisfying to interface with a spin-off because this type of interaction allows for "more academic" formats as compared to highly standardised (large) industry interfaces. Apparently though, and this is to summarise the scarcity of observations we have to offer on the subject of complex coordination, this is a rare experience. As a consequence, as far as the contents of interaction are concerned, we are unlikely to identify repercussions on research behaviour. A little more uncertain about the ambition to present an alternative to the obsession with large interfaces and to provide empirical evidence for less spectacular ways of doing science-industry, we now turn to the second path of exploration.

b) Interaction as a catalyst

With regard to all areas of research and innovation covered by PROKNOW case studies, scientific research is heavily dependent on technology. In other words, scientific knowledge is not only "applied" to high technology industry. Rather, such knowledge is generated there and shapes, at least to an extent, the agenda of scientific research (cf. Rosenberg 1994). As already indicated, the current section is no longer about the contents of interaction. We will therefore not focus on technology-in-science and science-in-technology. However, related to and by mediation of technology, a second observation is disclosed

which might give some guidance to our second path of inquiry. "Within the realm of engineering disciplines, techniques developed in one area frequently turn out to be useful in others" (ibid. 156). Are interactions between academic spin-offs and their parent institutes a catalyst (or even the origin) of these flows? If so, this should be reflected, if only in terms of a surface phenomenon, by a multiplication of contacts. At the other extreme, we might think of interactions between academic spin-offs and their parent institutes as drifting towards an ever increasingly exclusive pattern of relationship. Taking the parent institute as a reference point, the current section finds some evidence for the former trend and none for the latter.

Interaction with spin-offs may result in a multiplication of business contacts. Apparently, interaction with spin-off firms does not prevent parent institutes from interacting with more firms and with firms of a different size and type. Once having been involved in the creation of spin-off companies, parent institutes tend to more successfully and frequently attract third-party funding. In addition, they often receive regional and national awards which further increase their visibility. Fuelled by these mechanisms, contacts between spin-offs and parent institutes sometimes have a double-catalyst function: They generate new contacts in both academic and business fields. To state it in negative terms: without a catalyst dynamic, we do not expect small firms to have any impact on large public research institutes. Provided that the birth rates of both academic and corporate spin-offs differ sharply between regions (Karlsson & Johansson 2006, Casper 2007), we assume, that the creation of these firms and their interaction with established organizations further amplify "regional advantages" (Saxenian 1996). A number of PROKNOW case studies illustrate that interactions often take place in dynamic and growing environments and may modestly contribute to growth by multiplying contacts. At the organisational level, this has sometimes resulted in research profiles which are no longer compartmentalised. Some of the public research organisations which have been involved with academic spin-offs have started to define themselves as multi-mission organisations.

We cannot exclude that this pattern of development and growth has an overall bias towards the applied side of science. But we have no evidence for interactions developing towards an "exclusive" relationship. We have not found a single case study which would serve as an illustration for some sort of parasitic

relationship which would cut off the parent institute from its original environment.

c) The role of intermediaries

Focusing on interactions between spin-offs and parent institutes the role of professors is hard to overestimate. There is a professor-centric pattern of interaction, and we will have to account for this particular way of a personalised interface when we turn to the question of repercussions (see next chapter). On the other hand, parent institutes have technology transfer offices that act as professional intermediaries between the parent institutes and (all sorts of) private companies (Guston 1999). Both in terms of personalisation (relevance of the professor-centric pattern) and professionalisation (relevance of the technology transfer unit), there is some variety across and within case studies. The interesting question which then arises is whether strong intermediaries and strongly personalised interfaces coexist or whether strong intermediaries neutralise personalisation and its effects. Observations taken across PROKNOW teams broadly converge towards the following: interactions with small businesses continue to be managed on a case-by-case basis. This leaves a lot of freedom to the individual researchers involved. While the literature has shown concern regarding a growing corporatisation of public research institutes (responding to the opportunities and risks of commercialisation), we cannot confirm that public research units' interactions with private companies are systematically put under the review and the regime of professionals. Intermediaries do not act as buffers and do not absorb the dynamic which might result from interactions: the contrary is the case. We found that many intermediaries heavily relied on personalised interfaces. As a rule of thumb, one might state that sustained interaction presupposes personal continuity. If a research institute wanted to remain an academic partner of its spin-off firm, it should assure personal continuity. If it considered spin-off companies to be a risk and wanted to stop interaction and avoid its consequences, it would have to take actions which disrupt personal continuity. For certain, personalisation can take different forms and roles (Audretsch & Stephan 1996, Murray 2004). A professor *de facto* supervising a small regionally embedded engineering firm and a star scientist backing a biotech company preparing to enter the global market may have little in common. These differences, however, relate to different forms of companies. They are less relevant when it comes to the consequences of a personalised interface.

The last three sections may be summarised as follows. First, there is rarely interaction at the level of research groups which would justify speaking of "complex coordination". Second, while some cases expose a catalyst dynamic which is well-known from clustering studies, interaction between academic spin-offs and their parent institutes are not found to result in an exclusive relationship. Third, despite the existence of technology transfer units, interactions between spin-offs and parent institutes are heavily personalised. These findings put at risk our attempt to concentrate on interactions at the "medium level" of research groups.¹⁷ Trying to identify forms of doing science-industry, we are prepared to reach a sobering conclusion: what really matters, seems to be who is doing science-industry.

¹⁷ It goes without saying that there is no standard research group across disciplines and academic cultures. Even within the PROKNOW sample which covered only three (groups of) disciplines, research groups vary in terms of size and internal structure (hierarchy, etc.).

4. REPERCUSSIONS

Having set the stage by the previous steps of analysis on "lands" and "interactions", the current chapter reports on the repercussions of spin-off activities on their institutes of origin. Relating repercussions to the most common (or "black box") models of scientific production, namely the input and the output model, our findings remain rather scattered and unsurprising. In turn, our most striking finding relates to the internal organisation of research institutes. Contrasting a widespread interpretation, we cannot confirm that research institutes engaging in spin-off activities would inevitably end up as more corporate organisations. Rather, we claim that another aspect of repercussion is more relevant. In order to prepare for the concluding chapter, the current chapter also formulates a number of caveats on the limitations of our research model.

Once again, the question of repercussions has so far been absent from the research agenda. The bulk of studies set out to justify that academic spin-offs are an important subject of investigation for their economic impact. Of course, none of our fellow researchers would deny academic spin-offs to have an impact on the universities from which they originate. But their interest in impact rarely extends to the old core missions of universities and research organisations. Rather, it is highlighted that academic spin-offs, besides directly contributing to regional economic development, may produce income for universities and commercialise technology that otherwise would remain undeveloped (Shane 2004). In order to complete this picture, the following sections will report on repercussions according to the input and output models of science. The section on changes regarding the input side will mainly deal with changes in terms of "resources". The section on outputs will consider changes of knowledge production resulting from joint research activities and migrations of personnel. The third section returns to the question raised earlier: Who is really doing science-industry?

a) Repercussions according to the input model of science

Does interaction between academic spin-offs and their parent institutes result in changes with regard to the input model of science? Is there an increase in income? Do interactions result in a new distribution of incomes, either at the institute level or at the research group level? How about more indirect mechanisms

affecting the income of research organisations? This bundle of questions has been dealt with before, and we will not challenge the results presented by earlier studies. Increase in revenue due to commercialisation activities in general is low but constantly overestimated (Bok 2003). Notwithstanding the aforementioned tensions related to patenting issues, the aspect of "resources" does not seem to be an important dimension of repercussions in itself in any case. Direct monetary transfers between both parties are not significant. In a majority of cases, the presence of spin-offs is said to have agreeable side effects as they are taken as a certificate by funding agencies and large industry of the institutes' capacity to do science-industry and has therefore triggered large investments in a common research and development structure. To access third-party funding schemes may even be a motive to create a spin-off.

BioLand's interviewees tend to frame the issue of interaction as an equivalent of "to work for the company". Consequently, the question why anyone who is not on the spin-off's pay-roll (or has taken shares in it) should have an incentive to "work for the company" arises. This question is particularly difficult to answer in the case of junior researchers who seem to be structurally excluded from the beneficial effects of interacting with spin-offs in particular, and doing science-industry in general. On the other hand, there is a composite pattern of interaction which involves routine, resources, and reputation. All three ingredients are well known from the literature: star scientists lend legitimacy to risky business plans; academic spin-offs enjoy exclusive access to new patents within a circumscribed area of research. In exchange, the institute is provided with large quantities of high quality testing materials. These sorts of arrangements rely on local habits and expertise, but they obviously also depend on larger legal and institutional frameworks. Large investments to develop a coherent patent portfolio are considered to be a precondition for spin-off activities (and are often a lesson learned the hard way). As part of the deal, the parent institute and some of its senior researchers often take shares in these companies. As a consequence, a small minority of people (generally research directors or professors) have an incentive to closely interact with spin-off companies while ordinary staff members do not. This does not necessarily lead to a shift with regard to the institute's portfolio but may result in (further) isolating those who are doing science-industry.

Are these repercussions relevant to science policy? Borrowing from the most ordinary understanding, relevant science policy changes are those reflected in research funding. Research funding is conceived of as an interaction between two parties, namely researchers (and their spokespersons) and representatives of the funding bodies (who might turn to researchers in order to prepare funding decisions). As shown by Jane Calvert (2006), relationships between researchers and funding bodies are characterised by the use of a highly flexible rhetorical device, "basic science". It has been confirmed that academic spin-offs have an influence on funding decisions at the level of their parent institute. For instance, interacting with spin-offs results in easier access to funding, and it helps in diversifying, i.e. drawing on different sources of funding. But what about the output level? Does interacting with spin-offs result in a different sort of output?

In the majority of cases, the answer is no. We do not have appropriate and first-hand observations on whether research practice has been affected by interactions with academic spin-offs as we rely on empirical material gathered by interviews. Interviewees, the majority of whom are well-trained science-policy practitioners on their own behalf, are used to framing their responses as they do when interacting with funding bodies. In other words, responding to our questions, they tend to depict their own research as "basic research". Regardless of their nominal affiliation (to an applied or a basic science context), once they reach the level of their actual work, they would make an effort to describe it as driven by autonomous research interests. To simplify the argument put forward by Calvert (2006), they are likely to defend a zero hypothesis, and the rhetoric device of "basic research" helps them to do so. We explain elsewhere the methodological precautions taken which have allowed us to find out more than the most expectable response: "Whatever the circumstances, we will continue doing the same. We know how to make it look to get it funded."

b) Repercussions according to the output model of science

Do interactions with spin-off companies result in a shift towards the applied side of science? Do they entail extensions towards a broader portfolio including new mission? Do they lead to neglecting or transforming first and second missions?

To find empirical support for the "interactive model," movements of people back and forth between public research organisations and academic spin-offs have

been closely observed. The most salient examples can be found in the area of IT Land. Considering the cases of BioLand and NanoLand, interaction and repercussion are more consistently framed in terms of "resources" rather than "people". In IT Land, interaction between spin-off companies and their parent institutes mainly unfold around younger researchers at the stage of diploma theses. This finding is in tune with an observation of what may count as the most obvious difference between spin-off activities in the areas of IT Land and the other cases observed: People involved in the creation of spin-offs in the field of IT are younger than their counterparts in the other fields.

Diploma theses and PhD dissertations are often regarded to be a marginal aspect of the scientific production of knowledge. In this respect, PhD students simply don't count, although, especially in the life sciences, they represent a considerable share of the scientific workforce and, while being highly mobile, this sub-population actively contributes to the distribution of knowledge which would otherwise remain local, implicit and incorporated (Mangematin 2003). As stated earlier, the recruitment process of knowledge intensive firms' employees is not a one-off market transaction. On the other hand, even though the idea of writing a PhD thesis while working in a spin-off company is often abandoned, there are significant numbers of persons trying to combine scientific qualification and a small company job. Another aspect to be mentioned when it comes to the migration of persons (and personal knowledge) is temporary double appointments. While these are frequent in the Biotech area, they are almost absent in the IT area, except for very early career stages (diploma students). Dual roles in a wider sense, comprising advisory functions, may reach senior levels at the research institutes. They are commonplace throughout the case studies. If asked whether these various flows of staff have an impact on the output of science, interviewees tend to circumvent our question. Instead, they respond in terms of input claiming that research groups that are involved in spin-off activities are more active and more successful in applying for third-party funding. Although we did not have control groups to properly check this assertion, we agree that a correlation is easy to observe, even though a causal relationship would be hard to determine.

Reportedly, interaction reflected in flows of personnel has, at some places, lead to a higher visibility of universities. Especially if there is a steady flow of diploma students finding employment in adjacent academic spin-offs, this is likely to add

to the attractiveness of a particular department. While one might speculate that preparing students for small research-based company jobs may be a trigger for shifts in educational programs, we have no evidence, that curricula have been changed to respond to this demand.

On the other hand, indications for a shifting output in terms of more formalised knowledge and related to spin-off activities are weak. IT Land has a few examples which illustrate that interaction between academic spin-offs and their parent institutes has resulted in the creation of novel areas of academic research. In these cases, the company's product may be described as a generic device which has served clients in industry but also many research institutes, including the parent institute. Interviewees claim that this has triggered major innovations in scientific research and is mirrored by a significant amount of joint publications. However, even in those cases, the share of joint publications (including co-authors from parent institute and spin-off firm) as compared to the total publication output of the parent institute is low. We would like to underline, though, that these few cases are the only ones to combine two features of interaction mentioned in the previous chapter. Contrasting with other examples, these interactions are long-term and not limited to transactions of predefined products and services. They are multilevel interactions embedded in complex processes of coordination. What is more, we have found the spin-off and parent institute to be at the origin of developing generic tools and prototypes which have circulated widely and across sector boundaries.¹⁸

The history of BioLand's involvement in spin-off activities does not provide a similar success story. It is marked by a more reactive approach taken by the parent institutes following shocks related to the problems and costs of patent management. First, many BioLand parent institutes have lost revenues due to patents not protected in an appropriate way. Second, they have been shocked by the heavy investments necessary to protect patent rights. As a response to these shocks, numerous actions have been taken in order to reframe the function of "innovation" and "application" in order to make it look like a normal and

¹⁸ For historical case studies on the creation of generic technology and its conditions, see Joerges & Shinn (2001). Looking at our sample, we again underline that academic spin-offs are rarely involved in creating technology for generic uses. By implication, the creation of academic spin-offs rarely defies sectoral boundaries. Far from being drivers of sectoral change, we would argue that academic spin-offs occur as part of various processes of intra-sectoral reorganisation (outsourcing, etc.).

specifiable "mission". In some countries, this process is still underway. On the other hand, pointing to the small number of spin-off companies and their small size, interviewees deny that it has affected research agendas, career paths or evaluation criteria.

c) *Who is really doing science-industry, except a few (male) professors?*

The title given to the current section slightly alters a question from a key publication within the field of science studies. It brings together an impatient tone and anticipates the answer we will provide to the question dealt with in the former paragraphs. It impatiently seeks indications that go beyond the level of symbolic policies. Is there really change (or no change)? By personalising the question, we also simplify it. However, in our view, this simplification is justified by the results reported so far. To anticipate on our conclusion: if there are changes in research behaviour following the interaction with academic spin-offs, they consist in reinforcing an old European model of university relations based on personal dependency. As these repercussions are still very much in line with the academic cultures in a number of PROKNOW countries, they are often taken for granted. Having stated that to a surprising extent doing science-industry is channelled by a few persons, our diagnosis is distinct from that provided by Etzkowitz who finds research groups developing towards "homologous qualities with start-up firms". While many would regard this to be a frightening process, the author has pointed out that "[a]ttracting the best students and professors in some areas becomes an economic development strategy that expands the growth of the academic enterprise. Some of these changes are internal developments within the academy, such as the development of the research group that has firm-like qualities. Thus, the research university shares homologous qualities with a start-up firm, even before it directly engages in entrepreneurial activities" (Etzkowitz 2004: 77).

Having studied interactions between academic spin-offs and their parent institutes in a number of European contexts and in some detail, we have come to the conclusion that it is not research groups which adopt "firm-like" qualities. Rather, it is senior researchers that extend networks of personal dependency typical of the academic realm to firms originating in that context. To be sure, this revised picture simplifies a lot. For instance, it does not take into account differences in type and in size within the population of spin-off firms. Neither does it

do justice to the range of firms included in the PROKNOW sample. Leaving aside the variety of firms and of business models (we will come back to them later) we want to address another implication of the current practice of academic entrepreneurialism: what about scientific staff which has not yet gained a senior research position? With regard to the ways scientific professions and related career paths have been institutionalised, doing science-industry seems unlikely at an early career stage. Why sign up in science, why choose a scientific endeavour that requires a lot of precommitment if a higher salary were available in industrial research? And why put this career choice which requires, above all, signalling quality of freely available publications at risk by spending too much time on other activities (Dasgupta & David 1994)?

A BioLand professor reports to have lent his academic reputation to support the credibility of a spin-off firm. To our surprise and with uncommon frankness, he has officially declared having served as a fig leaf. Clearly though, he does not claim to actually do science-industry. Rather, he expresses reluctance about entering a game the rules of which seem rather suspicious. While his support might be useful to the burgeoning company, it remains an arbitrary gesture. On the one hand, his statement can be interpreted as a criticism of a common practice, turning towards those colleagues who have (more happily) embraced this questionable role in order to increase their reputation or their income. On the other hand, the founders of the academic spin-off company in question report that he has been under fierce criticism: Why should they be excluded professorial support if others (other companies emerging from academic contexts and/or researchers on academic career tracks) benefit from it?

d) Caveats

In order to show some limitations of our research model, three caveats on our observations on "interactions" and "repercussions" and the ways they relate to each other shall precede the concluding chapter. *First*, the temporal extension of "interaction" has not been specified. Interaction between two partners may be going on while one or both of them undergo transformation. Spin-off companies might change their orientation, grow, disappear, merge or split up. The same applies to research institutes. Within a period of observation, they may gain or lose organisational autonomy or coherence. They may grow or decline, fuse, enter complex partnerships with other research organisations or receive a new

role in a national sector of public research. These transformations have to be taken into account. Is it possible to assess "repercussions" if the object receiving an impact is a moving target? How not to overestimate the organisational stability of the partners involved in interaction? As stated earlier, by choosing the research group as a level of reference, we tried to capture the most dynamic level of research organisations.¹⁹ We admit this to be a weakness of our research model. On the other hand, in the case of the linear model, this reservation also applies. *Second*, another puzzling issue was brought up at several occasions throughout the report. Even if we succeeded in isolating "interaction" as a factor which influences "research behaviour" the research design is exposed to a high risk as the dependent variable is highly contested. It is often claimed that "research behaviour" is a set of activities the content of which is only defined by the standards of a scientific community and its particular epistemic culture. If directly confronted with the question "does interaction have an impact on research behaviour?", interviewees deny that "research behaviour" is affected at all. A detection of relevant shifts and changing patterns of research behaviour rely on the endogenous perspective of researchers who have a sound knowledge in their field. Inescapably and unsurprisingly, the bulk of researchers we encountered first adopted a protectionist attitude. If we have been able to delve further, it was thanks to analytical strategies borrowed from the repertoire of science studies described above. *Third*, inquiring about changes in research behaviour at the level of research groups, our argument has put much weight on the finding that science-industry interfaces are heavily personalised. At the same time this conclusion leaves us in an awkward situation because we are not in a position to observe changing dispositions of individual scientists.

¹⁹ To be clear, however, we have not encountered research collectives as described by Callon (2003) which would encompass, if only temporarily, both an academic spin-off and a research group at a public research institution.

5. CONCLUSIONS

In formulating conclusions, we have to recall that we deliberately skipped the usual format of case studies based on national perspectives and their respective (national) systems of innovation. We also refrained from delimiting our analyses to a certain type of research organisation. In that sense, we have adopted a procedure that contributes to further denationalising the understanding of science policy. On the other hand, we did not follow our colleagues and fellow EU-funded researchers whose approach is very much based on distinctions between different types of spin-off companies (Clarysse et al. 2005; see section 2a). They suggest that research organisations (should further) develop a distinct spin-off strategy depending on different company types.²⁰ By contrast, our analysis has given priority to interactions and left differences between company types in the background.

Provided with these clarifications, both further research and policy learning may benefit from a number of concluding reflections. First, we briefly comment on why "academic entrepreneurialism" has gained levels of attention which seem clearly disproportionate with regard to its real-life dimensions. We then compare these "spectres haunting Europe" with the results of our mundane attempts to construct case studies.

²⁰ To summarise their conclusions, parent institutes may either

(a) follow a low selective strategy approach which includes giving some support to the creation of small or micro-companies in order to secure employment for former students or research staff. This strategy is oriented towards generating the highest possible number of spin-offs. One might add that it has a strong affinity to parts of the IT sector.

(b) A second approach is explicitly oriented towards technology transfer, and to create spin-off firms is only one alternative among others to pursue this goal. Compared to the low selective strategy, it therefore requires a more complex and individually tailored set of support. One might add that the second approach has no clear sectoral affinity.

(c) The last strategy is called high selective and has led to highly professionalized support structures. In order to select a few cases that might attract the required amount of external capital and might promise considerable growth, a rigid procedure of selection is carried out. One might add that the third approach has an affinity to the biotech sector (for all three types, see Clarysse et al. 2005).

a) *Rise of entrepreneurship policy or another spectre haunting Europe?*

Is there a rise of a policy field to be dubbed "entrepreneurship policy"? Without referring to the particular case of academic spin-offs, Hart (2003) explains why this is unlikely to happen. While large industry has some power of negotiation - it may exert pressure by announcements to relocate; it seems unrewarding to invest in policy cycles for entrepreneurs and smaller, nascent businesses. Notwithstanding this more general obstacle to establish "entrepreneurship policy", one of its first issues would be to solve a major policy problem: How to create conditions under which these companies do more research or spend more money on research (Rosenberg 1990)? According to an almost uncontested view, this is a key for securing their competitiveness and the competitiveness of European economies.

Public policy has often failed to create conditions under which companies do more research or spend more money on research. Would it be helpful to multiply and intensify interaction between private firms and public research institutes instead? A large number of recent policies have been justified by referring to the interactive model. At some point, these initiatives seemed to add up to another spectre haunting Europe.²¹ With regard to our subject of analysis, interactions between academic spin-offs and their parent institutes, we recommend scaling down political expectations attached to the interactive model. Two simple recommendations can be formulated: First, do not expect interaction (between academic spin-offs and their parent institutes) to result in higher research expenditures by private companies and a significant source of funding for research organisations. Second, do not expect high levels of interaction between both parties unless this has a rewarding effect for the immediate context of origin of the academic spin-offs.

Reformulated in positive terms, we suggest that there are two policy options which are not necessarily mutually exclusive but should be jointly considered. In the line of the first recommendation, we suggest tightening the policy agenda with regard to economic and industrial policy goals: identify the few areas which are most likely to produce a financial return for parenting research organisations

²¹ For the symbolic uses of academic spin-offs, see Knie & Lengwiler (2008). For strikingly different policy approaches towards academic entrepreneurship across European countries, see Knie et al. under review.

and provide for large incentives. In the line of the second recommendation, it should be considered to broaden the policy agenda with regard to science policy goals. Adjust any new action to foster interaction (between academic spin-offs and their parent institutes) to the particular institutional layout of the public research organisation.

b) Absence of bad repercussions? Are academic spin-offs always good for science?

We have not found that academic spin-offs deteriorate the quality of scientific work. But we cannot conclude that, independent of the various forms of direct interaction between both parties, spin-off activities may have bad repercussions for science. To recall the most common issues, there may be conflicts of interests either between research groups and the central administration (on whether to support spin-off activities) or between different departments having more or less affinity towards commercialisation. Those more reluctant or opposed to spin-off activities may be right in their fears that the quest for private gain may undermine "open creation and dissemination of knowledge" (Shane 2004: 280) as researchers tend to withhold their results. Furthermore, conflicts of interest may arise if researchers have a choice between raising money for a company or conducting a research project. Here the conflict arises in terms of different sources of funding.

Obviously, then, there is a problem which relates to the failure of a spin-off firm. How much risk should public research institutes take when investing tax-payers' money into private firms? And what is an appropriate strategy of risk management if risk management itself creates new risks, for instance that of "living dead firms, unable to commercialize a piece of technology, but holding an exclusive license, these firms keep others from using technology" (ibid. 282)? This would not only have harmful consequences for science but also for application and innovation. There is no question that these are serious concerns. The public good character of universities has to be reconsidered the more they become entrepreneurial. Finally, to return to the focus of our analysis, while academic entrepreneurs may become rich, and tax-payers concerned about this, how about the research group level? We suspect that doctoral students largely contribute to the development of patents without being rewarded (cf. Shane 2004: 284). Therefore, if asked who has a problem with academic spin-offs (rather

than what is the problem with academic spin-offs), we strongly suggest to focus the discussion. It is the immediate context of origin (of academic spin-offs) that should be at the top of the long lists of those potentially suffering from harmful effects.

Academic spin-offs should not be regarded as another possible solution to the problem of low private investment in research. If policy frameworks were designed to promote that solution, they are likely to create reverse effects. In order to encourage close interaction at the interface between academic spin-offs and their parent institutes, more attention needs to be given to the immediate context of origin of the spin-off firm.

c) Incentives for transfer?

As economies have become more dependent on knowledge, economic growth has become "a hostage to rather fragile features of the cultural and institutional environment", namely academic science which needs to be "supported by public and private patronage" in a way as to remain "institutionally distinct from the world of profit-motivated corporate R&D" (Dasgupta & David 1994: 515). Adherents to this point of view acknowledge that there are "delays and failures in the process of transferring basic research findings from university laboratories to corporate R&D" (ibid. 516) but they regard these problems as inevitably resulting from a division of cultures. Somehow counter-intuitively then, the approach dubbed the new economy of science and innovation (ibid.) defends if not reinvents the (old) linear model. Economies are dependent on the constant production of scientific knowledge, but academic research ("Science" with a capital letter) and corporate R&D ("Technology", both in capital letters) continue to be distinct "realms". By implication, any attempt to tighten relationships between Science and Technology incurs high risks.

If one were to fully adopt this point of view, there is no room left to create incentives for commercialisation. Having taken a close look at how academic spin-offs interact with their parent institutes, we suggest adding another cautious note. There is "interaction", and it takes place on a regular and institutionalised basis but is often limited to senior staff of the research institute. These academic partners often have a mandate in the spin-off's consultancy board and are in charge to "report from new developments". In most cases, "interaction" is

a matter of keeping the person who has been at the origin of the idea leading to the creation of the spin-off "on board". To be kept "on board" generally means to be offered shares of the company. In exchange, the person commits him/herself to an often long and complicated process of clarifying the patent situation. Obviously, this kind of arrangement only comes up in cases where property claims matter, especially in the field of bio-therapeutics. Beyond these fields, "interaction" is not used as a category of "action" which could be further specified. It is rather understood as a category of disposition. Some academics who have been involved in "interaction" may behave "differently" but there is no need to question a simple model according to which academics may either display a disposition or the absence of a disposition to get involved with industry.

If no policy change is taken, who will really be doing science-industry tomorrow? The answer is sobering: no one except a few co-founding (most often) tenured professors. In terms of publications and their impact, some of them are "star scientists". Regarding the case of this small subpopulation, interaction (between academic spin-offs and their parent institutes) has been found to have a positive impact: Star scientists who get involved in spin-off activities continue to have an above average publication record. In other words, interactions between spin-offs and parent institutes are and will remain heavily personalised as the following mechanism applies: sustained interaction between both parties presupposes personal continuity, and it's only tenured academics who are in a position to ensure personal continuity. This overall trend has different implications. On the one hand, public research organisations relating to the Biotech sector will continue undergoing massive change in order to meet the demands of a few persons doing science-industry (as managing intellectual property requires centralisation). On the other hand, in the areas of IT, doing science-industry is also personalised but will continue to be a much more decentralised phenomenon (due to lower capital needs and shorter time to market).

Academic spin-offs can have a multitude of positive effects for parenting research institutes. Among the options to create conditions for good repercussions, we suggest rewarding those who stay with research groups which have accompanied the creation of spin-off companies. Depersonalising the science-industry interface presupposes that research groups (that stay at the research institute and accompany the creation of spin-off companies) are provided incentives, either financial or reputation – or both.

The obsession with academic spin-offs is in decline, and the present report may have contributed to that. Innovation does not necessarily stem from "new" science but from old science. This is, of course, difficult to accept by science policy makers who might expect (and promise) an immediate return of investment. Having focused on "doing science-industry" in the sense of direct interactions, we should not overlook the fact that technological innovation is often based on "old science" which may have developed in distant places. In other words, in many areas, doing science and doing industry are likely to remain fundamentally different things.

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6. ANNEX

a) *The PROKNOW research teams*

Since its kick-off meeting in Sofia Antipolis, in March 2006, the PROKNOW consortium met for steering committee meetings in Berlin (September 2006 and October 2006) at Twente University (June 2007), at EAWAG in Dübendorf, Switzerland (January 2008), in Sofia (September 2008) at a PROKNOW workshop with invited experts, and in Brussels (January 2009). The last meeting is also a conference and the consortium's major step towards a dissemination of research results. In addition, all national partners have organised midterm workshops between July 2007 and January 2008. Several PROKNOW national teams have hosted fellow PROKNOW researchers, ranging from a few days (Emanuelle Fortune, OFCE, and Arend Zomer, CHEPS, hosted by the WZB) to several weeks (Jürgen Enders, CHEPS, hosted by the WZB; Anke Borcharding, WZB, hosted by SPRU; Jari Kontinnen, VTT, hosted by CHEPS; Jörg Potthast, WZB, hosted by EAWAG). During early stages of the project, these "exchanges" of personnel contributed to develop a common research framework. Visiting arrangements have also lead to joint publications and helped to prepare future projects.

The coordinating team consisted of four persons: Anke Borcharding was in charge of interfacing with everyone; Jörg Potthast was in charge of writing reports, including the present one; Anke Borcharding and Jörg Potthast also carried out the German case studies; Dagmar Simon and Andreas Knie were in charge of supervising the coordinating activities. There was no change in staff throughout the whole period of research.

The remaining PROKNOW national teams consisted of three persons – excepting the Finish team (one person). Most PROKNOW national teams have been subjected to a fluctuation of staff – excepting the Dutch team. In one case, the supervising person has changed. Two teams have added staff (Bulgaria, Switzerland); three teams have replaced staff during the process of research (Finland, UK, France). The overall number of people who at one point were part of the PROKNOW consortium is 21: Ivan Tchalakov, Tihomir Mitev, Venelin Petrov (Bulgaria), Michel Quéré, Emmanuelle Fortune, Franck Paolucci

(France), Martin Meyer, Pablo d'Este, Basak Candemir (UK), Jürgen Enders, Ben Jongbloed, Arend Zomer (Netherlands), Pirjo Kutinlahti, Jari Konttinen (Finland), Bernhard Truffer, Kornelia Konrad, Eckhard Störmer (Switzerland), Andreas Knie, Dagmar Simon, Anke Borcharding, Jörg Potthast (Germany).

PROKNOW researchers have different qualifications, including economics, political sciences, and social sciences. Members of one PROKNOW research team (actually the coordinator) have been actively involved in academic entrepreneurship: Andreas Knie, WZB, has co-founded two companies in the area of transport and mobility services and research; Dagmar Simon, WZB, runs a small company that specialises in evaluation services but which is not called a "spin-off". Most PROKNOW research teams have "in house" experience with spin-off activities, including the Social Science Research Center Berlin (WZB) (Germany), VTT (Finland), the University of Twente (Netherlands), the Observatoire Français des Conjonctures Economiques (OFCE), the University of Sussex (UK), and the Bulgarian Academy of Sciences (Bulgaria). Two of these, namely the Science Park at Sofia Antipolis, and the Entrepreneurial University of Twente, are widely considered to be pioneering institutions in the area of technology transfer by means of the creation of research-based companies. Five PROKNOW teams, namely the French, English, Dutch, Bulgarian and the Finish team, have included local ("in house") case studies in their sample.

To conclude, PROKNOW research teams have been involved in academic entrepreneurship in different ways and to different degrees. Some have long-term observations of the career of a parent institution that terms itself "entrepreneurial". Others have a "minority" background, having tried to establish a company from a research environment which was indifferent if not hostile to this idea. These differences in experience have shaped the ways PROKNOW research teams have identified and accessed their respective case studies (as illustrated by the numerous "in house" studies). To some degree, these differences in experience have been made explicit throughout the research process and enriched its result. It may have contributed to successfully competing for research funds in the first place, and for completing the empirical part of the study, that the project consortium ranked high in terms of academic reputation but rather low in terms of entrepreneurial reputation.

b) Key documents

Conclusions and highlights from the *national* case studies

For further reading, please contact PROKNOW research teams.

Switzerland: Swiss Federal Institute for Aquatic Sciences and Technology (EAWAG), CIRUS, Dübendorf, Switzerland, Bernhard Truffer

While part of the spin-offs may be interpreted as following a more or less linear transfer model with only little interaction, there are many cases which are more appropriately interpreted as being engaged in a process of interactive knowledge production and innovation. Furthermore, there are indications that joint research projects between spin-off and parent unit are not just one form of science-industry interaction. While in most cases spin-off-related projects are quantitatively not very outstanding compared to other industry projects, joint projects are often particularly rewarding for the parent unit, since these are close to their agenda and research-intensive.

In most cases, a high intensity of interaction generated various synergies for the parent unit, mostly related to research, but in some cases teaching also profited from the spin-off relations. It should be stressed though that a high intensity of interaction is not a reasonable model for all spin-off-parent-pairs. It rather presumes a potential for synergies in the form of a high overlap of agendas. In addition, as has also been indicated by former studies, a personal involvement of parent unit researchers in the spin-off, either by taking on an operative position in the spin-off or a board position, seems to be necessary for maintaining intensive interactions in the medium-to-longer term. This is particularly noteworthy since double-staff appointments are likely to entail a high potential for conflicts of interests. Thus, it may be that the spin-offs contributing most to knowledge production are at the same time those which need most attention in order to avoid or manage conflicts of interest.

It furthermore became clear, that spin-offs which entertain little or no interactions with their parent organisation may have very different implications for the parent unit depending on the overlap of agendas. If the overlap is small, this is an adequate pattern of interaction. Substantial benefits for the research lab are

hardly to be expected though. If the overlap of agendas is high, however, partly indirect and sometimes also problematic effects may occur resulting largely from a competitive relationship between spin-off and parent unit. At best, potential synergies are not realised, e.g. because the spin-off is too small to invest in joint projects, etc. This constellation seems to occur mainly in the disciplinary fields of biotechnology and micro-/nanotechnology.

With regard to the repercussions on academic institutions we ascertained, two points are particularly noteworthy. First, the entire 'set' of repercussions which have been observed in the various cases by and large comprises the effects that have also been described by former research. By addressing effects at the research lab level, the contribution has been able to highlight effects that have not been given much attention. These relate to the research agenda of the lab as well as to organisational effects like the restructuring and rebuilding of research groups. These effects seem to depend on the specific institutional setting of the parent organisation, which may be a reason that they haven't been discussed in other studies focussing on universities alone.

Netherlands University of Twente, (CHEPS) Enschede, Netherlands, Jürgen Enders

Overall, the interactions differ significantly across the Dutch cases. In general the spin-off companies interact with the research institutes mostly within the context of government funded projects. Industry-sponsored contract research projects play a less significant role, although some cases involved significant contract research projects with industry. In our sample, most companies originating from PROs keep collaborating with their parent institute.

During the 1990s the funding environment of universities and PROs was made increasingly conducive to spin-off generation and commercialisation. In the Netherlands, several programmes and policy instruments were created to stimulate science-industry interactions. Since the middle of the 1990s, the large majority of research institutes in the Netherlands created support structures for the creation of spinoff companies. However not all PROs have created support structures and some PROs have been reluctant to actively engage in the support of commercialisation activities as they consider this not a part of their profile as scientific institutions. We find that the engagement in entrepreneurial ac-

tivities occurs differently across organisational levels. On the level of research institutes support structures for the creation of spin-off companies and commercialisation of knowledge have emerged almost uniformly in the Netherlands, taking to account some exceptions. For research institutes it is important to show to their government sponsors they are engaging in the production of knowledge relevant for society and the active commercialisation of knowledge since this enhances their legitimacy. On the level of the individual researcher, the creation of spin-off companies generally does not lead to changes in the research activities of researchers, nor does it significantly add to their relationship with other firms. While there is a large variety in types and intensity of interactions between spin-offs and their parent research institutes, hardly any evidence of a change in research activities or research agendas was found. Academic research agendas at best are inspired by the RBSOs, but are in general not affected in any substantial way by the spin-off companies since RBSOs are only a small part of the larger institutional environment of researchers which suggests that any influence coming from RBSOs is expected to be relatively small. Interestingly, researchers utilise the presence of spin-off companies to demonstrate to the outside world that relevant and applicable knowledge is being produced. Researchers strategically present their spin-off companies to legitimise the obtainment of funds from Dutch and EU funding sources, which stress public-private interaction in scientific research.

Overlooking the results from our empirical analyses we have to conclude that the parent institutes of spin-offs certainly remain close to their offspring and maintain contacts in various ways. However, like true parents, it is them that educate their children and not the other way around. Parent research institutes will however call upon their offspring when needs and/or opportunities (mostly of a financial nature) arise. The spin-off companies themselves often have too few resources and too short horizons to significantly affect the core activities of their parents. Or, to put it even shorter, spin-off companies from public research organisations are not very likely to make the academics' heads spin.

Finland: Valtion Teknillinen Tutkimuskeskus (VTT), Espoo, Finland, Jari Kontinen

The results of the Finnish case study suggest that the interaction between the parent institutes and their spin-offs is not very extensive; there is no remarkable

difference compared to business-as-usual industrial cooperation. Many times the cooperation seems to be coincidental; possible gains are not recognised within academia, and the research institutes have not developed any strategic partnerships with their spin-offs.

The results also suggest that there are only minor transformations in the research behaviour of the parent institutes. The possible “brain drain” (when key personnel move to a spin-off) was considered to be the most challenging part of spin-off activities. The positive flipside of the coin is that spin-offs provide significant career paths for researchers and students. Staff-exchange was, however, mostly a one-way activity from the parent institutes to the spin-offs.

Joint use of facilities, equipment and data was widespread in Finnish case institutes. This sharing process seemed to benefit both the parent institutes as well as the spin-offs; at least these resources are shared without hesitation and doubts among parent institutes and spin-offs. At best, the joint use builds stability in research work at the parent institutes and operates as a risk-sharing mechanism for the parent institutes and spin-offs. Moreover, the joint use of facilities and equipment seems to be more intense in the research field which is dependent of expensive infrastructure and equipment in research and production. Joint participation in third-party funded research projects (EU and Tekes) with spin-offs was quite common in every case institute. Spin-offs are often considered as “convenient” partners for third-party funded projects so there is a positive effect related to the existence of spin-offs; they indirectly contribute to the acquisition of third-party funding.

Another observation related to Finnish research institutes was that the mere existence of spin-offs may have a positive impact on the reputation and resources of the parent institute, especially if there are significant societal impacts expected. Active spinning-off may open new opportunities for acquiring research funding – it gives a proof for research financiers that research has practical benefits for the industry and society. On the other hand, there were indications that in some cases active commercialisation may not be regarded as a prestigious activity, especially among financiers of basic research.

It was quite challenging to assess whether interaction leads to transformation of research behaviour in terms of increasing the share of applied research. Most of

the interviewees considered that the interaction as such does not affect the emphasis of research. Instead, the dependency of external resources may redirect topics and emphasis of research projects. It is also possible that in these cases it did not become that visible since all of the case institutes were industrially-oriented research units which have a mission to carry out application-oriented research alongside academic basic research.

Finnish data suggests some more or less evident reasons for limited interaction and repercussions in our cases. First, all of the studied spin-off companies were rather small. As research and technology development are relatively expensive activities, for a small company it is almost impossible to commission contract research with a university department or a state research institute. In addition, small and fresh spin-offs do not need external R&D immediately after their establishment since they already have the latest know-how. Second, since they have adequate know-how in the field in which their parent institutes operate, they are more likely to seek partners from other technological fields. An example could be a biotech company which is developing medical diagnostics tools and needs knowledge on computer sciences or electronic engineering. Third, cooperative research is usually initiated and designed in the parent institutes, not in the spin-offs. This usually entails a situation in which the spin-offs are not able to influence the research behaviour of the parent institutes.

Bulgaria: Institute of Sociology - Bulgarian Academy of Sciences, Sofia, Bulgaria, Ivan Tchalakov

The Bulgarian contribution questions six key aspects of academic spin-offs and their relationships with parent institutions which are often taken for granted. It analyses the historical background of the phenomenon, and discusses elements of path-dependency.

First, academic spin-offs transferred much more to industry than just knowledge and research results. Often this was not even their main function: in some cases, using their experience in reverse engineering accumulated from the socialist period, the scientists became intermediaries between emerging private business and foreign companies entering East-European countries. On other occasions, with the entire sectors of the economy practically collapsing, the academic entrepreneurs became the sole providers of technical services and small-scale production of high- (or even low-tech) products.

Second, there was no asymmetry between academic spin-offs and the rest of the economy from the point of view of business and management skills – throughout the 1990s, they were at low level both in academia and in industry. In some cases, academic spin-offs were in the advantageous position regarding other economic actors because of the skills they acquired in the late socialist period in order to cope with reduced financing and the relative isolation of industry.

Third, there were hardly any deliberate policies towards academic spin-offs both at the government level and at parent institutions. In Bulgaria in particular, during the 1990s the lack of policy measure supporting spin-offs was accompanied by explicit efforts to restrict and even ban spin-off activities of the scientists.

Fourth, up until the beginning of this century, specialised financial support for academic spin-offs was practically nonexistent. There were no such special financial provisions for the spin-offs, and often they were additionally loaded by parent institutions to pay charges reach up to 30% of their profit. In addition, in a number of instances the academic entrepreneurs voluntarily used part of their profit to support the research and teaching process at their parent institutions, suffering from continuous underinvestment during transitional period.

Fifth, the ‘ambition to growth’ was present but, similarly to the developed countries, many academic spin-off firms in Eastern Europe remained small and did not grow. However, this was only true for certain economic sectors while in some sectors academic spin-offs had remarkable growth, e.g. in information and communication technologies, perfumery and cosmetics, industrial automation, machine-building, and some others sectors, academic entrepreneurs in fact provided the basis for the rebuilding of the sectors, and became key players in the new industrial structures.

Sixth, in Eastern Europe there was also a debate ‘pro’ and ‘con’ academic spin-off. It has, however, a different background and dynamics. Emerging as spontaneous bottom-up phenomena and as a possible solution to the severe problems faced by parent organisations, in the early years of transition the positive attitudes towards spin-offs dominated. The strong arguments against them appeared a few years later, and many universities and research organisations

even banned commercialisation efforts and restrained from applied research. In the rent-seeking economies imposed in some post-socialist countries, these measures were considered a protection from stripping out the expensive research equipment, and against the hidden privatisation of valuable research assets. In the post-transitional period of EU membership, the rising pressure to support innovations and upgrade industrial R&D again strengthened the positive attitudes towards academic spin-offs.

France: Fondation nationale des sciences politiques, Paris, France

Michel Quéré

The sample of academic spin-offs chosen in the French case studies is biased by the type of parent institutions which are applied-research oriented. However, even in this context, there is only a weak level of interactions parent institutes are pursuing with academic spin-offs as well as with the very few repercussions that the existence of academic spin-offs have on the evolution of the parent institute.

First of all, very few academic spin-offs continue to keep operational connections with their parent institutes when they have established themselves on the market. A strict boundary between basic or applied research and business seems still to prevail. Thus, doing research and doing business are dominantly perceived as two different purposes and, from our investigations, their alternative character prevails. Therefore, temporary mobility of scientists from the parent institute, contractual agreements for the benefit of the parent institute, joint scientific publications, and co-publication strategies are weakly noted in the interplay with the academic spin-off. It is like a sequential game whereby moving from the research parent institute to engage into business through an academic spin-off is a permanent choice that appears to be quite irreversible. The creation of an academic spin-off can even endanger the parent institute in that the whole set of human resources that shifts from public to private can ruin the capitalisation of the parent institute in the field. Formal relations nevertheless keep running from times to time in terms of standard connections such as the use of room facilities, of administrative and legal services, and even of the use of scientific equipment from the parent institute, even if those modes of relationships were not easily admitted by the spin-offs during the interviews. This again, however, seems to have no impact in terms of modifications in the science strategy of the parent institute.

Second, if formal relationships are weak, informal exchanges seem to subsist in various ways such as direct individual contacts, exchanges during conferences and seminars, and informal exchanges. In other words, the dominant skills and capabilities of public scientists seem to differ from the one at stake in academic start-ups. For instance, joint contributions to academic publications are rare, and that change in purpose, means, and behaviours is something that is taking place in a sort of natural process of dissociating the respective roles of parent institutes and academic spin-offs. In any case, neither formal nor informal connections allow considering that the academic spin-offs can have an incidental role on the strategic behaviour of the parent institute.

Third, the main benefit that parent institutes could have from academic spin-offs apparently lies in the reputation effect that their simple existence provides. In the institutional context we previously described, there is real concern about taking care of the budget constraints: exhibiting academic spin-offs obviously improves the legitimacy of the parent institute, and makes its strategic positioning easier, for instance when bargaining with central decision-makers about budget amounts.

Fourth, a further benefit for parent institutes lies in the further use of academic spin-offs in order to explore new financial opportunities. In some rare cases, when actual research connections are maintained between the two partners, they can work together to receive further funding from third party organisations (often public bodies). The alliance between public and private actors appears to be attractive in terms of further social benefits and, as such, increases the probability of succeeding in project submissions.

United Kingdom: The University of Sussex acting through SPRU - Science and Technology Policy Research, Falmer, Brighton, U.K., Martin Meyer

The report shows that the impact of spin-offs has limited benefits. Although there are instances of important financial contributions arising from spin-offs, these cases are limited to a few among many. Furthermore, even in the cases where financial contributions have occurred it has been noted that these are not that significant when compared with the overall income of the departments and universities, and first-stream funding continues to be the most important resource.

Based on its findings, the contribution argues strongly that spin-off activities do not have detrimental effects on the quality of academic research, neither at the institution nor at the academic level. At the institution level, there is no change in the research agenda towards more applied or less risky research. Academics themselves also stated that their research agenda had not changed and that, furthermore, they were able to do better research by accessing data, materials and interesting problems provided by their interaction with the spin-offs. Hence, there is no negative impact of academic spin-off activities on the research agenda or on academic norms. Academics identify their primary role as an 'academic' rather than an 'entrepreneur' and place the emphasis on research and publications rather than on commercialisation activities, as in the traditional scientific system. This is further reinforced by the ongoing evaluation mechanisms which place the bulk of the attention on publications.

The contribution shows that there are important intangible benefits of academic spin-offs on their parent institutions, especially in terms of signalling and attracting students, academics and industry parallel to an enhanced reputation. These findings include several aspects that are important for the policy makers, especially for assessments of spin-offs and for funding mechanisms. While current evaluations are able to capture part of the spin-off performances through indicators such as number, life span, turnover and so on, focusing on these indicators creates the risk of failing to observe the hidden impacts such as reputation and signalling.

The general conclusion is that spin-off activities are not detrimental to academic research. This finding should feed back into the larger discussion of whether commercialisation activities in general are detrimental to academic research or not. The hypothesis on the detrimental effects of spin-off activities is related to the question of 'who is not doing science?', as doing science-industry is sometimes associated with not doing science. Nevertheless, the report has shown that academics are able to do science-industry, along with science.

Considering that there is a strong relation between good quality research and success in commercialisation activities, the report emphasises that support for knowledge transfer activities must not be at the expense of research excellence at universities.

The contribution demonstrates that the issue of institutional heterogeneity is a further area of research that should be explored. This study has briefly touched upon the fact that the impacts of spin-offs can differ amongst universities depending on a number of factors such as previous history of industrial collaboration or the TTOs, even within the same category of institutions. Furthermore, this study has been limited to research-intensive universities and further research is necessary in order to establish whether similar assumptions can be made for less research-intensive ones.

Germany: Social Science Research Center Berlin, Germany, Andreas Knie, Dagmar Simon

International comparisons suggest that entrepreneurship could already be considered a component of the public-legal institutional landscape in the US and UK, whereas Germany continues to be shaped by the traditional dichotomy between academic research and economic activity. Meanwhile, there is continued debate on appropriate research policies. In research policy, spin-offs are edging away from having only a token function and instead are increasingly forming part of the modern innovation landscape. Indeed, recent science policy research suggests that the breaking up of conservative structures in the science system demands the mutual recognition of scientific and economic results as well as the acceptance of highly varied founding motives and business models. There is a large variety of motives why one could spin-off science: to set up a company, to develop a new career perspective, and to put scientific findings into practice. In particular, spinning-off seems to have gained a prominent position in the career planning of both students and scientists, though to a lesser degree in areas of high technology than in science-based services.

New options are currently mainly on offer in the transition process that comprises a significant part of the German science system. This process has led to a certain profiling of universities in particular, but also of non-university research institutions. These changes indicate a shift from the traditional generic university – embracing all disciplines from mathematics to humanities and aspiring to excellence in all of them – to the specialised form of a ‘thematic’ university with research excellence concentrated in just one or two fields. Moreover, premises and funding programmes in science policy can lead to entrenched specialisation. As a result, universities tend to have specific profiles. This enables some of them not only to position themselves as entrepreneurial universities but also to

pursue a strategic policy that includes ensuring there are appropriate conditions for the enhancement of knowledge transfer in research and teaching, and particularly for founding spin-offs. As spin-offs are anything but a homogeneous group and many cannot offer any significant contributions to the creation of economic value – such companies are rather the exception –, the expectations of the entrepreneurial university, but above all of science policy actors, for the economic potentials of spin-offs have to be put into perspective. The goal should be the integration of “third stream activities” into policy-making and the decision-making processes of the respective university. This would enable entrepreneurial activities to become an integral part of university governance, an approach that has already been practised for some time elsewhere. It is worth noting that spin-offs have traditionally been regarded as nothing more than a particularly refined form of (high) technology transfer, used to justify public spending on research. However, they are now becoming a new, versatile social reality which may well bring about wider acceptance for public spending on R&D.

Questionnaires

PROKNOW Interview guideline for questions targeted at the parent institute and, slightly modified, for the spin-offs

1. Localisation of the interaction

What are the departments or research groups at your institute which have been most actively involved in spin-off activities?

How would you best describe a researcher who is inclined to initiate spin-off activities?

Could you name a person at your department or faculty who has been involved more than once in the creation of a spin-off company?

Would you describe yourself as an academic entrepreneur?

Would you perceive spin-off activities as an alternative to other forms of knowledge transfer?

What is the relationship between these different forms of knowledge transfer at your institute?

Could you provide an indication of the number of patents and licences/royalties at the institute level?

Please name spin-off companies which in your opinion qualify as "research intensive".

2. Joint research output

Did spin-off activities have an impact on any of the following performance indicators?

Have there been or are there currently research co-operations between the institute and spin-off companies? Of what kind are they?

Are there co-publications with the spin-off companies?

Do spin-offs' employees take part in academic conferences?

Do employees of the reference spin-off take part in the teaching at the institute?

Do the employees of spin-offs consider themselves to be scientists?

How has the number of qualified publications developed since the beginning of spin-off activities?

How has the number of invitations to academic conferences developed since the beginning of spin-off activities?

How has the number of co-publications with the spin-off companies developed since their creation?

How has the number of patents developed since the beginning of spin-off activities?

Is there a relationship between the number of spin-offs and significant thematic and methodological shifts?

Have you noticed shifts to more or less “risky” research topics and methods since the beginning of spin-off activities?

Are research topics more customer-driven and application-oriented since the beginning of spin-off activities?

Do spin-off activities have an impact on the institute's or departments reputation within the relevant communities of research? Please specify!

Is there a (positive or negative) relationship between the number of spin-offs and the intensity of the co-operation with national and international research institutions?

3. Financial aspects of the interaction

What financial impacts do spin-offs have on the institute?

Do spin-offs play a role for the acquisition of third-party funds?

Has the share and the composition of the third-party funds changed since the beginning of spin-off activities?

Do spin-offs co-finance diploma thesis or dissertations?

Has the number and share of co-financed diploma thesis or dissertations changed since the beginning of spin-off activities?

Could you provide an indication of the number of at the institute level?

Does the institute generate spin-offs related income from consultancies, patents and licences/royalties?

Has the share of income from consultancies changed since the beginning of spin-off activities?

Does the institute derive income from sharing laboratories and buildings with spin-off companies?

Has the income from shared laboratories and buildings changed since the beginning of spin-off activities?

Do spin-offs co-finance teaching, research and conferences?

Has the share of co-finance teaching, research and conferences changed since the beginning of spin-off activities?

Has the institute become a customer of the spin-off and/or vice versa?

Have there been moments of competition between the institute and its spin-off(s)?

Has the institute received gifts and donations for buildings or professorships since the beginning of spin-off activities?

4. Personal aspects of the interaction

What are the personal effects of spin-offs for the institute?

Do you know of any researcher who has given up a full-time and permanent position to create a spin-off firm?

Do you know of any scientists have returned from the spin-off to the institute?

Are there persons simultaneously employed by both a public research institute and a spin-off company?

Are spin-off companies among the potential employers for the institutes' graduates?

What are the career opportunities available to spin-off personnel?

Which prerequisites are necessary to ensure the success of simultaneously promoting a spin-off while still being able to fulfil the necessary research work?

Is your institute affected by a brain drain due to the spin-offs?

Which impact has this brain drain on the research programme and the research output?

5. Organisational aspects of the interaction

When confronted with a spin-off project, does the institute follow a general policy guideline with regard to the management of intellectual property rights?

Have there been significant changes regarding this policy guideline?

Was the guideline relevant to your case?

Do you observe stable patterns of a division of labour between parent institute and spin-off?

Did spin-off activities have an impact on the intensity of industry contacts of the institute?

How important to the institute's scientists are publications and lectures addressed at a non-academic audience?

Has the institute intensified its contacts in industry due to the spin-offs?

Did spin-off activities have an impact on the activity profile of the institute?

Did spin-off activities result in a diversification of the institute's activities?

Is there a relationship between the intensity of spinning-off and increasing evaluation requirements?

Are there further relevant indicators to measure the repercussions?

6. Relevance of spin-off companies for the science system

How do spin-off processes and activities affect the overall scientific performance?

With regard to evaluation criteria and science policy frameworks, what is the main lesson to be learnt from your involvement in spin-off activities?

Dissemination

Partner: WZB

Type of product: Discussion paper within the "PROKNOW series on science policy studies"

Title: The Project Group Science Policy Studies Production of Knowledge Revisited: The Impact of Academic Research Performance in Europe. Abbreviated description of the research project funded by the European Commission, Discussion paper P 2006-102

Date: 2006

The Discussion paper in PDF-format is available on the Internet www.proknow-eu.de/publications.htm

Partner: WZB

Type of product: Contribution to a conference

Title: FP6 - Priority 7 - Project Management Conference, held on 8/9 June 2006 in Brussels Anke Borchering: Project presentation on the PROKNOW project

Date: 8 - 9 June 2006

The Presentation is available on the Internet

Partner: WZB

Type of product: Contribution to a conference

Title; Conference of the European Association for the Study of Science and Technology (EASST), 23.-26.8.06 in Lausanne, Jörg Potthast organising and chairing the panel: Science Between Peer Review and Profit Rate: Academic Spin-Offs – Chances and Perils for Public Research?

Date: 23 - 26 August 2006

The conference programme is available on the Internet [www.proknow-eu.de/](http://www.proknow-eu.de/THREAD%209,SESSION%209.3,page%2038) THREAD 9, SESSION 9.3, page 38 of the programme

Partner: WZB

Type of product: Contribution to a conference

Title: Jörg Potthast: Die Kontinuität der Innovation. Interaktionen zwischen akademischen Ausgründungen und ihren Herkunftseinrichtungen. Presented at the Sektionstagung Wissenschafts- und Technikforschung & Arbeits- und Industriesoziologie, Universität Dortmund

The conference programme is available on the Internet [www.proknow-eu.de/](http://www.proknow-eu.de/inhouse) inhouse

Date: 12 October 2007

Partner: WZB

Type of product: Dissemination on the Internet

Title: Website www.proknow-eu.de with inhouse area

Date: Since 2006

Partner: CHEPS

Type of product: Contribution to a book

Title: Kees Eijkel & Arend Zomer: Commercialisation strategies for public research organisations: How to move from public research out into the market by a leading Dutch institute, Chapter 5 in: David Tolfree: Commercialising Micro-Nanotechnology Products: realization of marketable micro-nano products from concept to end- product development.

The book chapter is available on the Internet www.proknow-eu.de/ inhouse

Date: 2006

Partner: CHEPS

Type of product: Contribution to a conference

Title: Arend Zomer, Ben Jongbloed, Juergen Enders Kees Eijkel & Arend Zomer: Do spin-off companies make the academics' heads spin?

Paper presented at the EGOS conference in Amsterdam 10-11 June 2008

Partner: UoS

Type of product: Editor of a special issue of a refereed journal

Title: "Research Policy", "Triple Helix indicators of knowledge-based innovation systems"; Volume 35, 2006, Issue 10, pp 1441-1674, edited by Loet Leydesdorff and Martin Meyer

Date: 2006

Partner: UoS

Type of product: Chair of session at conference

Title: 4S (Social Studies of Science) Conference in Montreal, Canada

Date: 11-13 October 2007

STS & Information Studies IV: Mapping science

Session 4.2, Thursday October 11, 1h45-3h15.

Organizers: Jean-François Blanchette, Geoff Bowker, Loet Leydesdorff

Chair: Martin Meyer, SPRU, Sussex University.

Participants:

Willam Turner, Nicola Ferey, LIMSI (withdrawn).

Stasa Milojevic, UCLA

Diana Lucio Arias, University of Amsterdam.

Loet Leydesdorff, University of Amsterdam

Diana Rhoten, Social Science Research Council (withdrawn)

Discussant: Alberto Cambrosio, McGill University.

Further information is available on the Internet:

www.4sonline.org/meeting07.htm

Partner: EAWAG

Type of product: Contribution to a conference

Title: Kornelia Konrad and Bernhard Truffer contributed to the European Association for the Study of Science and Technology (EASST) conference 2006, held August 23-26 in Lausanne:

The coupling of spin-offs and research institutions in the triangle of policy, science and industry.

Date: 2006

The conference programme is available on the Internet [www.proknow-eu.de/THREAD 9, SESSION 9.3, page 38](http://www.proknow-eu.de/THREAD%209,%20SESSION%209.3,%20page%2038) of the programme

Partner EAWAG

Type of product: Discussion paper within the "PROKNOW series on science policy studies"

Title: Kornelia Konrad and Bernhard Truffer: The Coupling of Spin-offs and Research Institutions in the Triangle of Policy, Science and Industry – An International Comparison-, WZB Discussion Paper P 2006-103.

Date: 2006

The Discussion paper in PDF-format is available on the Internet www.proknow-eu.de/publications.htm

Partner: EAWAG

Type of product: Conference Presentation

Title: Kommerzialisierungseffekte: Eine institutionalistische Perspektive auf Interaktionen zwischen akademischen Ausgründungen und ihren Mutterorganisationen, GWTF Tagung, Universität Bielefeld

The conference programme on the Internet www.gwtf.de/archiv/2007-programm.pdf

Date: 23 -24 November 2007

Partner: IS-BAS

Type of product: Conference paper

Title: National innovation systems and Academic spin-off: The Bulgarian Case
The paper was presented at Research Workshop in *Entrepreneurship, Innovations and Competitiveness*, Economic institute, Skopje University (January 30, 2008) in Bulgarian language. It summarizes some of the theoretical and empirical data from the Project PROKNOW under the VI Framework Program of EC, Priority area 7

The paper is available on the Internet www.proknow-eu.de/publications.htm

Date: 25.01.2008 – Conference, Institute of Economics, Skopje, Macedonia

Partner: IS-BAS

Type of product: Book

Title: Academic Spin-off in Bulgaria, to be issued in 2009

Matrix of case studies

(as used during intermediate stage of interpretation, provided for the purpose of exemplary illustration)

Case Study				BioLand	IT Land	NanoLand	NanoBioLand
Sector characteristics							
		Need for expensive infrastructure (spin-off and/or parent)		Parent and spin-off both need expensive infrastructure for research and development	Highly flexible facility management on the university campus (in terms of office space)	Parents and spin-offs share facilities sporadically	Parent and spin-off intensively share facilities to have access to expensive facilities and to keep costs low
		Typical time-to-market of spin-offs		Time to market is long compared to ICT and nano	Immediate if not very short (1 year)	Short (1-2 years)	Short (1-2 years)
		Importance of IPR		IPR matters in 4 out of 5 sub-cases and is sometimes a hot issue over years	Most firms included in the sample are software-related: no importance	Use of IPR differs. Restrictive IPR-arrangements impede spin-offs	No importance
		<i>Typical size of spin-offs (as proxy for capital availability/intensity)</i>		Sample includes fairly small companies; their average size is about 15	Capital intensity is low; number of employees varies between 3 and 20	Sample includes small companies; their average size is about 10	Capital intensity is moderate; average size of companies varies between 2 and 30
Organisational features							
		Type of organisation		PRO	University, PRO, PPP	Cluster	University
		Mission (importance of teaching, research, technol-		No teaching (except for professors), key missions in Public Health	All three types of organisation are committed to collaboration in	Teaching is part of mission; institute focuses on fundamental	Mission of TT has recently materialised: A centre for including

		ogy transfer; importance of applied and/or fundamental research)		Monitoring and Education, recently constructed mission of biomedical innovation	the field of technology transfer. Key missions are broadly complementary: Teaching (university), research (PRO), applied research (PPP)	and on applied problems; the needs of industry is taken into account. Technology transfer is part of mission and implemented; spin-offs are by-products	costly laboratory infrastructure has been created. This mission is coupled with research but decoupled from teaching
		Number of spin-off companies investigated		5	5	5	3
Patterns of Interactions							
		Intensity of interactions between spin-off companies and the parent organisation, qualified and specified with respect to...	People	Frequent but temporary double appointments; professors taking over advisory roles use the degrees of freedom provided by their status	Double appointments absent except for early stage in academic career (diploma students)	Dual roles are a partial phenomenon; department chairs hold positions in spin-off advisory committees and boards; intense interaction on a personal routine level	No interaction
			Information	Share of joint publications is low (as compared to institute's overall output)	Share of joint publications is low (as compared to institute's overall output)	Share of joint publications is low (as compared to institute's overall output)	Share of joint publications is low (as compared to institute's overall output)
			Resources	In 2 out of 5 cases, spin-offs contributed significantly to the resource base of a research group and of the institute	Spin-offs have been important in order to gain funds for research but do not directly contribute money to the parent institute	Sharing facilities and knowledge, supportive co-operation, no direct contribution	Creation and survival of spin-off firms is a condition for the financial support of the mixed research centre
Repercussions							
	Output						
		Contribution to research capacity (e.g. by jointly		Spin-offs contributed to a modest increase of research capacity	Modest increase of publication	Spin-offs did not contribute to research capacity	The foundation of the centre itself was a repercussion of spin-off

		acquired projects & directly commissioned projects)					activity. Modest increase of publication
		Scientific reputation of individual researchers / groups		Top scientists have further increased their reputation; involvement in spin-offs can be detrimental to scientific career (2 sub-cases)	Positive impact on funding decisions; return to academic career path is difficult but not impossible	Positive impact on funding decisions supposed; no impact on an individual level	No influence reported
		Research agenda		Research agenda is not constrained but extended thanks to data and measurement techniques made available by spin-offs	In 2 out of 5 sub-cases, the spin-off has been a catalyst for major scientific breakthroughs	Research agenda was always application oriented, no changes due to spin-off activities	Any influence denied
	Activity profile						
		Changes with regard to 1st stream activities:	Create research partners?	4 out of 5 spin-offs regularly take part in collaborative research projects, only 1 with its parent institute	Spin-offs are regularly involved in collaborative research projects	Spin-offs are involved in collaborative research projects	Any influence denied
			Sharing of infrastructure?	An important investment in infrastructure is in preparation	(Nascent firms on campus benefit from cheap office space)	Occasionally	All parties benefit from major infrastructure investment
		Changes with regard to 2nd stream activities (teaching)					
		Changes with regard to 3rd mission activities		The parent institute had to build up capacities for handling patent issues	No changes reported	No changes reported	Thanks to the platform, 3rd stream activities are experienced on an everyday basis
	Personnel						
		Changes in career		Spin-offs do not play	Spin-offs are an impor-	Spin-offs are an em-	Negligeable

		paths (job opportunities, brain drain & gain)		an important role in terms of job opportunities. No brain drain reported	tant employer of students and PhDs	ployer of students and PhDs, but firms are too small, no job market	
		Change in attitude		Institute is more sensitive to financial risks (burden of patenting)	No recent changes	Institutes gained business experience on a personal level	Centre is perceived as a distinct and distant entity. No changes in attitude
	Reputation & Legitimation						
		Shifts in reputation due to spin-off activity at the level of the organization and its science policy context		Institute is considered to be a pioneer with regard to commercialisation and tries to maintain this reputation	One of the institutes builds its reputation on a radical strategy of diversification: One third of employees leaves for (creating) spin-offs	Spin-off activities are used for the institutes reputation	No shifts but diversification of missions has been broadly accepted
		shifts in reputation due to spin-off activity within the parent organization		Research groups frequently involved in commercialisation are more visible than others	Spin-offs positively affect the reputation of research groups (even if only one firm was created)	Spin-offs are in interest for students as job opportunities	No changes reported

