WZB Wissenschaftszentrum Berlin
für Sozialforschung

Jörg Potthast

Re-thinking science-industry relations along the interactive model. The case of academic spin-offs

WZB Discussion Paper SP III 2009-603

March 2009

Social Science Research Center Berlin (WZB)
Research Group "Science Policy Studies"

Jörg Potthast, WZB
potthast[at]wzb.eu

SUGGESTED CITATION/ZITIERWEISE:

Potthast, Jörg, 2009: Re-thinking science-industry relations along the interactive model. The case of academic spin-offs. WZB Discussion Paper SP III 2009-603. Berlin: Wissenschaftszentrum Berlin für Sozialforschung.

Social Science Research Center Berlin (WZB)

Research Area Society and Economic Dynamics

Research Group Science Policy Studies

Wissenschaftszentrum Berlin für Sozialforschung gGmbH (WZB)

Forschungsschwerpunkt Gesellschaft und wirtschaftliche Dynamik

Forschungsgruppe Wissenschaftspolitik

Reichpietschufer 50, D-10785 Berlin
Telefon: +49 30 25491-0, Fax: +49 30 25491-684
www.wzb.eu

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 the present contribution analyses 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 money. 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 research teams in Bulgaria, Finland, France, Germany, the Netherlands, Switzerland, and the UK are based upon approaches in the economics of innovation, organisational sociology, studies on higher education and science studies.

Zusammenfassung: Akademische Ausgründungen sind private Firmen, deren Gründung in direktem Zusammenhang mit einem Wissens- und Technologietransfer aus einer öffentlichen Forschungseinrichtung oder einer Hochschule steht. Diese unmittelbare Beziehung ist an Patenten oder an Personen zu erkennen, die in die Ausgründung wechseln. Auf der Grundlage dieser Definition analysiert der vorliegende Beitrag Interaktionen zwischen öffentlichen Forschungseinrichtungen und akademischen Ausgründungen. Anhand einer recht kleinen Zahl von Fallstudien wird dieser Begriff von „Interaktion“ weit ausgelegt. Interaktionen umfassen Bewegungen von Personen (zwischen beiden Typen von Organisationen), gemeinsame Aktivitäten der Wissensproduktion sowie Ressourcenströme. Für drei Forschungs- und Innovationsbereiche – IT, Biotechnologie und Nanotechnologie – führt die Analyse von Interaktionen zu einem feinkörnigen Bild der Rückwirkungen, die sich aus diesen Interaktionen ergeben. Der Beitrag geht auf ein EU-Forschungsprojekt mit Partnern in Bulgarien, Deutschland, Finnland, Frankreich, den Niederländen und aus dem Vereinigten Königreich zurück. Es werden Ansätze aus Innovationsökonomie, Organisationssoziologie, Hochschulforschung und Wissenschafts- und Technikforschung kombiniert.

Contents

1. INTRODUCTION[1]

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 current contribution 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

[1] The present document reports on "The Production of Knowledge Revisited: The Impact of Academic Spin-offs on Public Research Performance in Europe (PROKNOW)", a three year research project funded within the 7th priority ("Citizens and governance in a knowledge based society") of the 6th European Commission Framework Programme. A prior version of this paper has been prepared for the final presentation of the research project in Brussels (21 January 2009). Comments by participants of this conference have helped to streamline the argument. Contributors to the research project are the National Foundation of Political Sciences, Paris, France (Michel Quéré, Emmanuelle Fortune, Franck Paolucci), the Science and Technology Policy Research Unit, University of Sussex, Falmer, Brighton, U.K. (Martin Meyer, Pablo d'Este, Basak Candemir), the Technical Research Centre of Finland, Espoo (Pirjo Kutinlahti, Jari Konttinen), the Centre for Higher Education Policy Studies, University of Twente, Netherlands (Jürgen Enders, Ben Jongbloed, Arend Zomer), the Institute of Sociology, Bulgarian Academy of Sciences, Sofia (Ivan Tchalakov, Tihomir Mitev, Venelin Petrov), and the Center for Innovation Research in Utility Sectors, Swiss Federal Institute for Aquatic Sciences and Technology, Dübendorf, Switzerland (Bernhard Truffer, Kornelia Konrad, Eckhard Störmer). The Research Group Science Policy Studies, Social Science Research Center Berlin, assumed its coordination (Andreas Knie, Dagmar Simon, Anke Borcherding, Jörg Potthast). All PROKNOW research teams mentioned have approached a large number of people who have been involved in spin-off activities. Many of them have been ready to share their views and experiences. While the current paper does not analyse the resulting corpus of semi-structured interviews in detail (but draws on more aggregated interpretations provided by the national research teams), it has been its major empirical foundation. Many thanks to all participants!

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. Arguably, 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.[2]

Academic spin-offs are private firms founded in direct connection with a transfer of knowledge or technology from public research facilities or universities.[3] This direct relationship is established through patents or persons who transfer to the spin-off. Based on this definition the present contribution analyses interactions between public research institutions and academic spin-offs. 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? More generally speaking, the project aims at re-conceptualising science-industry relations along the "interactive model". For this purpose, the "in-

[2] For an attempt to evaluate the tightened European agenda in matters of innovation policy, see European Commission, Directorate-General for Research (2008). The issue of interactions between science and industry has been put on national science policy agendas, too. For instance, the German Research Council has recently compiled a document reporting on various forms of interactions (Wissenschaftsrat 2007).

[3] Within our 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-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 research teams 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 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 research 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 research 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).

teractive model" has been brought to an area of research and policy which has been largely dominated by the "linear model".

While the linear model presupposes that knowledge trickles down from science to its industrial application, the interactive model emphasises on two-way traffic including flows of people, joint activities of knowledge generation, and flows of money. Taking interactions between academic spin-offs and their parent institute as a subject of investigation, the present contribution brings the "interactive model" of science-industry relations to the light of empirical analysis. Developing a framework for empirical analysis, it seeks to 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. On the other hand, turning to the interactive model, it has adopted a perspective on academic spin-offs which is unlikely to contribute to the question of their economic success or survival. Instead, the paper will systematically explore how academic spin-offs relate to their context of origin, i.e. the scientific field. *To put it more technically, it seeks to identify interactions between academic spin-offs and their parent institutes and to assess the impact of this interaction (on the parent institute).*

As a unit of analysis, the paper focuses on links between two types of organisations, namely public research organisations and firms which originated from them. To explore these interactions, three basic dimensions are taken into consideration, namely interaction in terms of people, in terms of joint activities of knowledge generation, and in terms of money and other tangible resources (see annex). Following a common strategy of sampling, a variety of different types, both on the side of spin-off companies, and on the side of parent institutes, has been covered by the research project this paper draws on. 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).

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 (too) 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 practical issues and problems encountered while trying to overcome the linear model and to adopt a perspective closer to the interactive model are dealt with in chapter 3. This chapter will also explain why the paper uses a rather supple definition of academic spin-offs, and why it has 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 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", "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 4 presents the results of the 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, the focus is on interactions between academic spin-off companies and research groups. With regard to this particular level, the 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 5 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, the most striking finding is about the internal organisation of research institutes. Contrasting a wide-spread interpretation, research institutes engaging in spin-off activities, be it for the purpose of patent portfolio management, do not inevitably end up as more centralised and corporate-like organisations. Rather, another aspect of repercussion is more relevant. To a considerable extent, doing science-industry depends on a

single person (often enjoying the degrees of freedom of a professorship). Whether this finding may be taken to confirm the "interactive model" is a puzzling question.

Chapter 5 also includes a number of caveats which help to better understand the research model. What kinds of "repercussions" are likely to be captured by using the described path of inquiry? For instance, as no long term observations are collected, there is no way to observe changing dispositions of individual scientists. Another caveat is due to the absence of control groups. As a consequence, the analysis does not follow a straightforward mode of hypotheses testing. For instance, the research design does not support general claims on whether academic spin-offs are bad for science.

To anticipate on the conclusions (chapter 6), the paper deliberately skips the usual format of case studies based on national perspectives and their respective systems of innovation. It also refrains from limiting the analyses to a certain type of research organisation at the outset. On the basis of these caveats, the conclusions will raise the following points. First, the paper will show that intensities and patterns of interaction vary along the lines of the mentioned areas of research and innovation. While this features as an 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.

"Academic entrepreneurialism" has gained levels of attention which seem clearly disproportionate with regard to its real-life dimensions. The current paper suggests contrasting these "spectres haunting Europe" with a mundane attempt to construct case studies. 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. Therefore, it is the immediate context of origin of academic spin-offs which needs to be put centre stage.

2. SHIFT

The current chapter turns to a few threads of literature most relevant to developing the research question. Among other things, it will discuss claims that, in recent times, interaction between science and industry has intensified and forms of interaction diversified. It will comment on efforts to capture industrial research as an object of research and evaluation. And it will delve into work that is critical of the commercialisation of science. Covering a great variety of research, the review of literature will try to prepare a *shift in perspective*. Instead of taking the birth and survival of spin-off companies as a dependent variable, small clusters of these firms and the ways they interact with their parent research organisation will serve as the independent variable.

a) 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, Bal-

timore: 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), 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.[4]

b) 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 (cf. Malerba 2002). Therefore, there can be no political strategy to turn areas marked by "roundabouts" into areas of direct transfer. We agree with this conclusion. Interestingly then, Pavitt quotes research train-

[4] By taking the research group as the centre of our attention, we try to get as close as possible to "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.

ing to illustrate the roundabout model. The direct model is said to be epitomised by academic spin-offs (Pavitt 2004). Transfer via academic-spin-offs is often thought of as being the most 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. 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, in terms of an object of policy and research, they 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, nor has their number been significant enough to justify hopes of a shift towards "direct" transfer.[5]

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

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

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 the following consideration: 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 paper 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 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 the single case of academic spin-offs. 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 our 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.

c) 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 insist 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.[6] 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

[6] Note that these figures rely on estimates provided by the companies themselves.

more recent counterpart: The display of being useful to industry as delivered by many research institutes throughout all countries represented in our sample.

d) 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 affects 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 commer-

cialisation 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,[7] 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 (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

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

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.[8] The issue is 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.

[8] 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?"

3. LANDS

As stated before, the current chapter retraces our strategy of sampling and casing. To begin with, 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 (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 under artificial titles ("IT Land", etc.) we intend to indicate our efforts of constructing case studies. On the one hand, 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.[9] 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.[10]
(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, PROKNOW research teams have worked on 35 case studies, 13 of them covering IT, 12 covering biotechnology, and 10 covering nanotechnology.

[9] Note that the size of "parent units" or "sub-units" varies between case studies. Some local research 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.
[10] 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. By this, we do not imply that smaller spin-off firms are of no significance with respect to economic development and innovation. Observing academic spin-offs in a postsocialist economy the study by Tchalakov (et al. under review) particularly insists on their economic significance.

The local 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 research 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 provided assistance. They would know best whether there are five spin-off companies and whom to approach for interview requests. By and large, all research teams 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.[11] 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) Interviews

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, members of our 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

[11] Some 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.

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 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 seem appropriate.

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 members of our research project? 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 (of the firms). 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.[12]

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 approaching interviewees and of constructing cases, we have also deconstructed pre-established ways of thinking about academic spin-offs and their parent institutes. While the linear model seeks to explain how policies and institutional frameworks impact on distributions of spin-off activities across institutions, regions or sectors, we have suggested taking the interactive model seriously.

[12] 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.

4. 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 reinterpret 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.[13] 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

[13] 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 predefined 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".[14] 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.[15] 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

[14] 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.

[15] Double-staff appointments are rare throughout all countries covered by this study. They are usually limited to short periods of time and, even then, are reported to be a source of conflict.

simultaneously try to pursue the path of scientific qualification. To return to and 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. Also, partly overlapping agendas make the continuation of linkages between academic spin-offs and their parenting research groups particularly rewarding. However, despite considered a matter of convenience (low costs of search and transaction and high overlap of agenda) there is a scarcity of observations we have to offer on the subject of complex coordination. 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 our 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 our 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 case studies 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 region-

ally 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.[16] 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.

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

5. 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. Only the analysis provided by the UK research team mentions "instances of important financial contributions arising from spin-offs" but adds that "these cases are limited to a few among many". In a majority of cases, academic spin-offs are not even a candidate for significant revenues due to their small size. On the other hand, 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. In some cases, this has triggered large investments in common research and development structures.[17] As a result, parent institutes and academic spin-offs frequently share expensive research facilities (neither party would have been able to deploy on its own). In some cases, to access funding for expensive research infrastructure has even been 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

[17] NanoLand has many examples to illustrate this. It is somehow confusing whether to take the existence of these "centres" and "platforms" as a result or "repercussion" of interactions (in the sense of the present paper) – or rather as an expression of political will to stimulate them. In view of this problem, we found it particularly challenging to interpret the NanoLand case studies which therefore ended up underrepresented in the present paper.

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 (cf. Krücken et al. 2009). 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.

b) Repercussions according to the output model of science

Does interacting with spin-offs result in a different sort of output? We do not have appropriate and firsthand 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 autonomous and independent from external changes. 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 only by 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 re-

search" 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 like to get it funded."

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 money and other tangible 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 if short term 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.[18] 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

[18] Some report that brain drain via spin-off companies is an issue in research institutes devoted to applied research.

be at the origin of developing generic tools and prototypes which have circulated widely and across sector boundaries.[19]

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 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. On a reflexive note, the vast majority of contributions (national reports to the PROKNOW research project) reviewed for the present paper restate these claims. They are anything but reluctant to (even) think of changes in research agendas resulting from interactions with academic spin-offs.

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 talk and symbolic policies decoupled from research practices or organisational missions. 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

[19] 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.).

dependency. As these repercussions are still very much in line with the academic cultures in a number of European 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 our 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 from professorial support if others (other companies emerging from academic contexts and/or researchers on academic career tracks) benefit from it? The example provided points to a source of conflict arising from spin-off activities which is more rarely considered.

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? We admit this to be a weakness of our research model which has become particularly obvious in our attempt to map interaction within a matrix (see annex). *Second*, another puzzling issue was brought up at several occasions throughout this paper. 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.

6. CONCLUSIONS

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.) has close affinities with the (old) linear model. Economies are dependent on the constant production of scientific knowledge, but academic research (“Science”) and corporate R&D ("Technology"; both "Science" and "Technology" in capital letters) continue to be distinct "realms". By implication, any attempt to tighten relationships between Science and Technology incurs high risks. While science policy making is often confined to this view of defending autonomy, innovation policy makers indefatigably highlight the need for interaction between public research organisations and private companies. As stated in the introduction, the present contribution has set out to take the interactive model of science-industry relations (more) seriously. Concluding remarks will first address the question if there is (new) evidence in support of the interactive model. It will then try to elaborate on policy implications, with a particular emphasis on the issue just mentioned: Does taking "interactions" more seriously allow for re-calibrating science and innovation policy goals and the way they relate to each other?

a) The future of the interactive model is uncertain

Having taken a close look at how academic spin-offs interact with their parent institutes, our conclusions open on a cautious note. There is "interaction", and it takes place on a regular and institutionalised basis but it 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". In some areas, to be kept "on board" 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 (then) "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. While these considerations including the observations on more everyday uses of the term should not be read to falsify the interactive model, we take them as a serious indication of its explanatory range. Interviewees consistently and convincingly expressed that interaction was confined to the individual level.

Based on a limited sample, we would also claim that well known sector characteristics like "capital intensity" and "time to market" are relevant to capture varieties and intensities of interaction. We are therefore inclined to question the commonly held assumption that academic spin-offs defy sectoral boundaries. In other words, rather than being drivers of sectoral change, academic spin-offs take part in various processes of intra-sectoral reorganisation (outsourcing, etc.). While these observations on the sector-boundedness of interactions remain partial, we find them to set further limits to the claim of an all-encompassing "interactive model". Within the sample under investigation, only a few cases display 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.

Academic spin-offs can have positive effects for parenting research institutes. Most strikingly, and often despite of low levels and intensities of interaction, spin-off activities have a long term impact on the reputation of a research organisation. Even a one-off experience can imply that the "market test" has been passed and facilitates access to current public funding schemes.

Provided that relations between academic spin-offs and their parent institutes cannot be described as heavily interactive, are we therefore ready to subscribe to the linear model? Should we just return to the view that innovation "stems" from science? Our findings leave us uncertain with regard to this question. On

the one hand, there is little justification to carry on being obsessed with academic spin-offs as some sort of fast track from scientific inquiry to innovation, regardless of whether this sort of transfer is described as strictly linear or in terms of an interactive process. On the other hand, our analyses did not escape an asymmetry built into the distinction of the linear and the interactive model. While the interactive model is related to "new science", the linear model is much more comprehensive as it might as well be applied to innovations that "stem" from scientific research in distant times and distant places. Still more confusingly, the interactive model is sometimes presented as some sort of "accelerated" linear model (by science and innovation policy makers who promise an immediate return of investment).

Who will actually be doing science-industry tomorrow? The answer is disillusioning, especially to policy makers-turned-proponents of the "interactive model": 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).

b) Re-calibrating innovation and science policy goals?

Recent policy recommendations in the area of academic spin-offs have primarily addressed the level of public research organisations. Recalling that academic spin-offs take different forms and different roles within innovation processes, public research organisations are advised to formulate their strategies

accordingly (Clarysse et al. 2005; see section 3a).[20] This recommendation comes with a more general message which is further backed by the present contribution: Considering that academic spin-offs are created and evolve within different contexts will help to establish a more realistic view on the size of the phenomenon. "Academic entrepreneurialism" has gained levels of attention which are clearly disproportionate with regard to its real-life dimensions.[21] There is no match between this recent "spectre haunting Europe" and the results of our mundane attempts to construct case studies and to analyse interactions between academic spin-offs and their parent research organisations. While this is too fragile a basis to formulate sound policy recommendations or to develop new policy options, we still think that we can refer to a question which is commonly held to be the foundation of innovation policies: 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.

It goes without saying that public policy has often failed to create conditions under which companies do more research or spend more money on research. More recently, this problem has been tied up with the issue of cooperation between private firms and public research organisations.[22] The interactive model

[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 lead 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).

[21] For a historical account on how academic spin-offs have been inflated by policy discourses, see Knie & Lengwiler (2008) and Knie et al. under review.

[22] 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

has raised political expectations: 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? 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. 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 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. This is fairly in line with policy implications made explicit by earlier studies: 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 (Mustar et al. 2008).

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

---

critically on collaborative networks involving academic and business enterprise research" (http://ec.europa.eu/research/reports/2004).

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? 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.

7. REFERENCES

Audretsch, David B. & Paula E. Stephan, 1996. Company-scientist locational links: The case of biotechnology. The American Economic Review 86, 3: 641-652.

Bok, Derek Curtis, 2003. Universities in the marketplace: The commercialization of higher education. Princeton: UP.

Callan, Bénédicte, 2001: Generating spin-offs: evidence from across the OECD. STI Review (OECD), 26, Special Issue Fostering High-tech Spin-offs: A public strategy for Innovation: Pp. 13-56.

Callon, Michel, 2003: Laboratoires, réseaux et collectifs de recherche. Pp. 693-720 in: Philippe Mustar & Hervé Penan (eds.), Encyclopédie de l'innovation. Paris: Economica.

Calvert, Jane, 2006. What's special about basic research? Science, Technology & Human Values 31, 2: 199-220.

Casper, Steven, 2007: How do technology clusters emerge and become sustainable? Social network formation and inter-firm mobility within the San Diego biotechnology cluster. Research Policy 36: 438-455.

Clarysse, Bart, Mike Wright, Andy Lockett, Els Van de Velde & Ajay Vohora, 2005. Spinning out new ventures: A typology of incubation strategies from European research institutions. Journal of Business Venturing 20, 2: 183-216.

Cohen, Wesley M. & Daniel A. Levinthal, 1990: Absorptive capacitiy: A new perspective on learning and innovation. Administrative Science Quarterly 35: 128-152.

Croissant, Jennifer & Sal Restivo (eds.), 2001. Degrees of compromise. Industrial interests and academic values. Albany: New York State UP.

Dasgupta, Partha & Paul A. David, 1994. Toward a new economics of science. Research Policy 23, 5: 487-521.

David, Paul A. & Bronwyn H. Hall, 2006. Property and the pursuit of knowledge: IPR issues affecting scientific research. Research Policy 35, 6: 767-771.

Etzkowitz, Henry, 2000: The second academic revolution: MIT and the rise of entrepreneurial science. London: Gordon and Breach.

Etzkowitz, Henry, 2004. The evolution of the entrepreneurial university. International Journal of Technology and Globalisation 1, 1: 64-77.

European Commission Directorate-General for Research, 2008. Lisbon strategy: Between revolution and illusion. The governance challenge for knowledge policies. Synthesis Report of the Lisbon Expert Group, Printed in Belgium, 48 pp.

Feldman, Maryann & Pierre Desrochers, 2004. Truth for Its own sake: Academic culture and technology transfer at Johns Hopkins University. Minerva 42, 2: 105-126.

Felt, Ulrike & Brian Wynne. 2007: Taking European knowledge society seriously. Report of the expert group on science and governance to the science, economy and society directorate, Directorate-General for Research, European Commission. January 2007. 95 pp.

Franzoni, Chiara & Francesco Lissoni, 2006. Academic entrepreneurship, patents, and spin-offs: critical issues and lessons for Europe. WP n. 180 September 2006: 33 pp.

Geuna, Aldo & Nesta, Lionel J. J., 2006. University patenting and its effects on academic research: The emerging European evidence. Research Policy 35 (6), 790-807.

Grandin, Karl, Nina Wormbs & Sven Widmalm (eds.), 2004. The science-industry nexus: History, policy, implications. Sagamore Beach, MA: Science History Publications.

Guggenheim, Michael, 2005: Organisierte Umwelt. Umweltdienstleistungsfirmen zwischen Wissenschaft, Wirtschaft und Politik. Bielefeld: Transcript.

Guston, David H., 1999: Stabilizing the boundaries between US politics and science. The role of the office of technology transfer as a boundary organization. Social Studies of Science 29, 1: 87 111.

Hack, Lothar & Irmgard Hack, 1985. Die Wirklichkeit, die Wissen schafft. Zum wechselseitigen Begründungsverhältnis von "Verwissenschaftlichung der Industrie" und "Industrialisierung der Wissenschaft". Frankfurt a. M.: Campus.

Hart, David M., 2003. Knowledge, power, and entrepreneurs: A first pass at the politics of entrepreneurship policy. In David M. Hart (ed.), The emergence of entrepreneurship policy: governance, start-ups, and growth in the U.S. knowledge economy. Cambridge: UP, pp. 227-238.

Joerges, Bernward & Terry Shinn (Eds.). 2001. Instrumentation between science, state and industry. Dordrecht: Kluwer.

Karlsson, Charlie & Börje Johansson, 2006: Dynamics and entrepreneurship in a knowledge-based economy. Pp. 12-46 in: Charlie Karlsson, Börje Johansson & Roger Stough (eds.), Entrepreneurship and dynamics in the knowledge economy. London, Routledge.

Kleinman, Daniel Lee & Steven P. Vallas, 2001. Science, capitalism, and the rise of the "knowledge worker": The changing structure of knowledge production in the United States. Theory and Society 30, 4: 451-492.

Knie, Andreas & Martin Lengwiler, 2008. Token endeavors: The significance of academic spin-offs in technology transfer and research policy in Germany. Science and Public Policy 35, 3: 171-182.

Knie, Andreas, Martin Lengwiler, Dagmar Simon & Tim Flink, under review. From token endeavors to role models of innovation? On academic spin-offs, their rationales and operating modes for science policy. Manuscript, 14 pp.

Knorr Cetina, Karin D., 1981. The manufacture of knowledge: An essay on the constructivist and contextual nature of science. Oxford: Pergamon.

Konrad, Kornelia, Eckhard Störmer, Bernhard Truffer, Arend Zomer & Jari Konttinen, under review. Symbiosis or emancipation? Interaction patterns mediating the impact of spin-offs on their parental research organisations. Manuscript, 49 pp.

Krücken, Georg, Frank Meier & Andre Müller, 2009: Linkages to the civil society as 'leisure time activities'? Experiences at a German university. Science and Public Policy 36, 2: 139-44.

Latour, Bruno & Steve Woolgar, 1986 (1979). Laboratory life: The construction of scientific facts. Princeton: UP.

Lowe, Robert A. & Claudia Gonzalez-Brambila, 2007. Faculty entrepreneurs and research productivity. Journal of Technology Transfer 32, 3: 173-194.

Lowen, Rebecca S., 1997. Creating the Cold War University: The transformation of Stanford. Berkeley: California UP.

MacKenzie, Donald A., 2004. Relating science, technology, and industry after the Linear Model. In Karl Grandin, Nina Wormbs & Sven Widmalm (eds.), The Science-Industry Nexus: History, Policy, Implications. Sagamore Beach, MA: Science History Publications, pp. 305ff.

MacKenzie, Michael, Peter Keating & Alberto Cambrosio, 1990. Patents and free scientific information in biotechnology: Making monoclonal antibodies proprietary. Science, Technology, & Human Values 15, 1: 65-83.

Malerba, Franco, 2002. Sectoral systems of innovation and production. Research Policy 31: 247-264.

Mangematin, Vincent, 2003. Les doctorands entre production et transfert de connaissances: Le cas des sciences de la vie. In Philippe Mustar & Hervé Penan (eds.), Encyclopédie de l'innovation. Paris: Economica, pp. 539-554.

Mirowski, Philip, 2008. The commercialization of science and the response of STS. In Edward J. Hackett, Olga Amsterdamska, Michael Lynch & Judy Wajcman (eds.), The handbook of science and technology studies. Cambridge: MIT Press, pp. 635-689.

Mowery, David C., Richard R. Nelson, Bhaven N. Sampat, and Arvids A. Ziedonis (Eds.). 2004. Ivory tower and industrial innovation: University-industry technology transfer before and after the Bayh-Dole Act. Stanford: UP.

Murray, Fiona, 2004. The role of academic inventors in entrepreneurial firms: Sharing the laboratory life. Research Policy 33: 643-659.

Mustar, Philippe, 2003a. Création d'entreprises à partir de la recherche. In Philippe Mustar & Hervé Penan (eds.), Encyclopédie de l'innovation. Paris: Economica, pp. 519-538.

Mustar, Philippe, 2003b. Politiques de soutien à la création d'entreprises de haute technologie. In Philippe Mustar & Hervé Penan (eds.), Encyclopédie de l'innovation. Paris: Economica, pp. 627-644.

Mustar, Philippe, Clarysse Bart, Wright Mike, 2008: University spin-off firms: Lessons from ten years of experience in Europe. Science and Public Policy 35: 67-80

Owen Smith, Jason & Walter W. Powell, 2002: Standing on shifting terrain: Faculty responses to the commercialization of knowledge and its uses in the life sciences. Science Studies, 15: 3-28.

Owen-Smith, Jason, 2006. Commercial imbroglios. Proprietary science and the contemporary university. In Scott Frickel & Kelly Moore (eds.), The new political sociology of science. Institutions, networks, and power. Madison: Wisconsin UP, pp. 63-90.

Pavitt, Keith, 2004. Changing patterns of usefulness of university research. In Karl Grandin, Nina Wormbs & Sven Widmalm (eds.), The science-industry nexus: History, policy, implications. Sagamore Beach, MA: Science History Publications, pp. 119-132.

Piore, Michael J., & Charles F. Sabel. 1984. The second industrial divide: Possibilities for prosperity. New York: Basic Books.

Potthast, Jörg & Michael Guggenheim, 2008. Are academic spin-offs really doing science? WZB discussion paper SP III 2008-602: 28pp.

Powell, Walter W., Kenneth W. Koput & Laurel Smith-Doerr, 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. Administrative Science Quarterly 41: 116-145.

Rabinow, Paul, 1997: Making PCR: A story of biotechnology. Chicago: UP.

Rappert, Brian, Andrew Webster & David Charles, 1999. Making sense of diversity and reluctance: academic-industrial relations and intellectual property. Research Policy 28 (8), 873-890.

Riehemann, Kristina, Arnold M. Raem, Wolfgang Buscher & Harald Fuchs, 2007. CeNTech - Nanotechnological research and application. Journal of Business Chemistry 4, 1: 3-10.

Rosenberg, Nathan, 1990. Why do firms do basic research (with their own money)? Research Policy 19: 165-174.

Rosenberg, Nathan, 1994. Critical issues in science policy research. In Nathan Rosenberg (ed.), Exploring the black box: Technology, economics, and history. Cambridge: UP, pp. 139-158.

Rosenberg, Nathan, 2003: America's entrepreneurial universities. Pp. 113-137 in: David M. Hart (ed.), The emergence of entrepreneurship policy: Governance, start-ups, and growth in the U.S. knowledge economy. Cambridge, UP.

Saxenian, AnnaLee, 1996: Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Harvard: UP.

Schmoch, Ulrich, 2003. Hochschulforschung und Industrieforschung. Perspektiven der Interaktion. Frankfurt a. M.: Campus.

Shane, Scott, 2004. Academic entrepreneurship: University spinoffs and wealth creation. Williston, VT: Edward Elgar.

Shinn, Terry & Erwan Lamy. 2006. Paths of commercial knowledge: Forms and consequences of university-enterprise synergy in scientist sponsored firms. Research Policy 35, 10: 1465-1476.

Sydow, Jörg, 1998. Understanding the constitution of interorganizational trust. In Christel Lane & Reinhard Bachmann (eds.), Trust within and between organizations. Conceptual issues and empirical applications. Oxford: UP, pp. 31-63.

Tchalakov, Ivan, Tihomir Mitev & Venelin Petrov, under review. Academic spin-offs as an engine of economic transition in Eastern Europe. A path-dependent approach. Manuscript, 24 pp.

Tuunainen, Juha, 2005: Contesting a hybrid firm at a traditional university. Social Studies of Science 35, 2: 173-210.

Wissenschaftsrat, 2007. Empfehlungen zur Interaktion von Wissenschaft und Wirtschaft. Oldenburg, 134 pp.

Wright, Mike, Bart Clarysse, Philippe Mustar & Andy Lockett, 2007. Academic entrepreneurship in Europe. Cheltenham: Edward Elgar.

Zomer, Arend, Ben Jongbloed & Jürgen Enders, under review. Do spin-offs make the academics' heads spin? The impact of Dutch spin-off companies on thier parent research organisation. Manuscript, 22 pp.

8. 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 Borcherding, 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 Borcherding was in charge of interfacing with everyone; Jörg Potthast was in charge of writing reports; Anke Borcherding 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.

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) Questionnaire

(Excerpt of the PROKNOW interview guideline; used in interviews with parent research organisations and, slightly modified, with academic spin-offs)

1. Localisation of the interaction

[…] - 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?

2. Joint research output

[…] - Are there co-publications with the spin-off companies?
[…] - Is there a relationship between the number of spin-offs and significant thematic and methodological shifts?
[…] - Do spin-off activities have an impact on the institute's or departments reputation within the relevant communities of research? Please specify!

3. Financial aspects of the interaction

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

4. Personal aspects of the interaction

- What are the personal effects of spin-offs for the institute?
[…] - Are there persons simultaneously employed by both a public research institute and a spin-off company?
[…] Is your institute affected by a brain drain due to the spin-offs?

5. Organisational aspects of the interaction

[…] - Do you observe 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?
[…] - Did spin-off activities result in a diversification of the institute's activities?

c) Coding scheme for the corpus of semi-structured interviews

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

BioLand

Codes (Dynamic of interaction; flow of interaction)	**Quotes (professor; CEO of academic spin-off)**
Joint production of knowledge; complex coordination	PROF: “That‘s when we suggested: ‘Hey, this [particular substance] should be used in the experiment!’”
Resources; catalyst	PROF: “As a long term consequence of this particular spin-off, the institute has attracted a large industry contract.”
0; 0	CEO: “The academic spin-off was sold to a pharmaceutical company which soon after went bankrupt. This is how interaction came to a sudden end.”

IT Land

Codes (Dynamic of interaction; flow of interaction)	**Quotes (professor or CEO of academic spin-off)**
Resources; catalyst	CEO: “As long as the company is well, the university chair will be fine, and vice versa.”
Resources; intermediaries	PROF: “This time, I was highly motivated not to abandon the idea and its potential for commercialisation.“
Joint production of knowledge; complex coordination	PROF: “The spin-off company has led to the valorisation of the highly theoretical context it emerged from.”

d) Overview of selected case studies along different sectors

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

Case Study				**BioLand**	**IT Land**	**NanoLand**	**NanoBioLand**
Sector characte-ristics							
		Need for expen-sive infrastructure (spin-off and/or parent)		Parent and spin-off both need expensive infrastructure for re-search and develop-ment	Highly flexible facility management on the university campus (in terms of office space)	Parents and spin-offs share facilities sporadi-cally	Parent and spin-off intensively share facili-ties 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 soft-ware-related: no impor-tance	Use of IPR differs. Restrictive IPR-arrangements impede spin-offs	No importance
		Typical size of spin-offs (as proxy for capital avail-ability/intensity)		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 aver-age size is about 10	Capital intensity is moderate; average size of companies varies between 2 and 30
Organisational features							
		Type of organisa-tion		PRO	University, PRO, PPP	Cluster	University
		Mission (impor-tance of teaching, research, technol-ogy transfer; im-portance of ap-plied and/or fun-damental re-		No teaching (except for professors), key mis-sions in Public Health Monitoring and Educa-tion, recently con-structed mission of bio-medical innovation	All three types of or-ganisation are commit-ted to collaboration in the field of technology transfer. Key missions are broadly comple-mentary: Teaching	Teaching is part of mission; institute fo-cuses on fundamental and on applied prob-lems; the needs of industry is taken into account. Technology	Mission of TT has recently materialised: A centre for including costly laboratory infra-structure has been created. This mission is coupled with re-

		search)			(university), research (PRO), applied research (PPP)	transfer is part of mission and implemented; spin-offs are by-products	search 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 acquired projects & directly commissioned projects)		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 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 a 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 paths (job opportunities, brain drain & gain)		Spin-offs do not play an important role in terms of job opportunities. No brain drain reported	Spin-offs are an important employer of students and PhDs	Spin-offs are an employer of students and PhDs, but firms are too small, no job market	Negligeable

		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