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Analysis of sector mobility

Cases

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Content

Case 1

Department of Electronic Systems at AAU

1.1 THE UNIVERSITY AND THE REGION

Aalborg University is a novel institution in the Danish university landscape. From its establishment in 1974, the university has been an important driver of regional development in the peripheral region of Northern Jutland. Furthermore, the university utilizes an innovative problem-based form of learning in its educational activities, whereby students work in interdisciplinary teams and solve real-life challenges in society or businesses. This is known as the Aalborg model.

The university has approximately 22,000 students and 4,000 employees. Within Engineering and Technology, Aalborg University ranks as number 79 in the world in the QS ranking system. Likewise, in the Shanghai Ranking system, Aalborg University's engineering and technology programmes are ranked among the top 100 in the world.

In national statistics of university-business collaboration, Aalborg University stands out on several innovation performance indicators. In 2014, the university spurred 50 licenses, sales- and options-agreements as the best performing Danish university on this parameter[1]. Furthermore, Aalborg University is the Danish university that have most research agreements per 1 bn DKK research budget[2].

1.2 ABOUT THE CASE

Among the examined universities, Aalborg University is among the institutions that displays the clearest strategic approach to sector mobility. The university has developed a model for part-time professorships, in which senior researchers from industrial partners e.g. Bang & Olufsen and Nokia Siemens Networks, work part-time at the university's research environments (typically 20 per cent of their time). Concurrently, the university operates a model in which associate professors at the university work part-time at the companies' R&D-divisions.

These models for sector mobility have especially been used at the Faculty of Engineering and Science. In this case, we will zoom in on the Department of Electronic Systems, in which these models were first put to use.

Based on our general analysis framework, the following table shows specific factors that we find decisive for the relative high degree of sectoral mobility in the present case.

[1] Danish Agency for Research and Innovation (2015): "Kommercialisering af forskningsresultater - og kortlægning af vidensamspil i bredere perspektiv"

[2] IRIS Group for the Danish Agency for Research and Innovation (2014): "Vidensamarbejde under Lup".

Decisive factors for a high sector mobility at the Department of Electronic Systems

AAU	ICT-cluster and industrial corporations in Northern and Western Jutland
• Problem-based learning model • Long-standing, trust-based R&D-relations with large corporations. • Strategic decision • Personal relations and motivation • Innovative models for shared professorship	• Access to industrial oriented talent pool • Access to ground-breaking research at the Department • Co-location of business and research at campus

The Department of Electronic Systems was one of the first research environments at Aalborg University, and has been an important breeding ground for the later development of other departments at the university. E.g. the Department has played a major role in the establishment of the Department of Computer Science, the Department of Mathematics as well as the Department of Health Science and Technology.

The research activities are focused on areas such as signal processing, wireless communication and control in industrial processes. The societal applications of the research include autonomous drones, new communication standards, e.g. for internet-of-things, as well as audio technologies and signal processing for hearing aids and loudspeakers, and the complex electronical systems of wind-turbines. The Department employs approximately 250 people, including approximately 110 senior researchers and 110 PhDs.

The environment has from the beginning been closely linked to the ICT cluster in and around Aalborg. Its research was an integral part of the development of the Nordic mobile telephone system (NMT) – the world's first multinational standards based mobile telephone network and a foundation for the later development of the GSM-standard.

Furthermore, during its history the cluster was the location of companies such as Dancall, Ericsson, Motorola, Alcatel and Nokia Siemens Networks as well as a wide array of ICT-related start-ups. All companies that tapped into the research and talent pool of the university. But during the first decade in the millennium, the cluster was struck by crisis brought about by the technological disruption by the new 3G-standard.

The crisis resulted in many corporations moving their operations out of Aalborg. However, the competencies in the area and the business-oriented outlook of the university and the Department remained. Today, the Department collaborates closely with large companies such as Nokia Siemens Networks, Bang & Olufsen, Oticon, and Grundfos.

1.3 EXTENT OF SECTOR MOBILITY

Aalborg University employs approximately 600 senior researchers at associate professor and professor level. There are in total 10-20 part-time ingoing shared professorships operational at the university, and five of them at the Department of Electronic Systems.

The Department has in collaboration with Bang & Olufsen established four "outgoing" 20 per cent associate professorships in which senior researchers from the university spend 20 per cent of their time at Bang & Olufsen.

The part-time industrial professorships have especially been utilized with researchers from Bang & Olufsen and Nokia Siemens Networks, but also companies such as Oticon and Grundfos have senior employees working as researchers at the University.

The shared professors are treated without prejudice as senior professors at the Department. Thus, they must fulfil all typical requirements of a professorship, including research, teaching and innovation activities. In practice, however, the 20 per cent employment does put certain limits on their portfolio at the university, and the primary emphasis is hence on supervision of PhDs and overall management of collaborative R&D projects.

1.4 EFFECTS OF SECTOR MOBILITY

The interviewed researchers and the Head of Department of Electronic Systems are generally coherent in their depiction of the following positive effects on research and education following from sector mobility;

Culture, organisation and internal cooperation. The Department already had a very symbiotic relationship to industry before the arrangements were made. One informant notes that the "mobile" researchers add an additional layer to these relations by bringing elements of corporate culture more directly into the research environment, e.g. structure, result-orientation etc. Also one mobile researcher points out that he is trying to introduce a more pro-active, result oriented culture into the research environments. For instance, this involves attempts to speed up research projects and IPR-processes at the university.

Other effects come in the form of their understanding of "two worlds", and knowledge on the "language" that is employed in private companies. For the other researchers, the mobile researchers act as a two-way translator, converting business concepts and language into research language and theories, and vice versa.

Research Focus. The sector mobile researchers have, to some extent, given rise to new research areas at the Department and are opening new venues in existing ones. For example, the Nokia Siemens Networks-affiliated part-time professor at AAU works with automation of drones based on their knowledge on mobile communication. The professor from Bang & Olufsen works with perceptual models for advanced audio-systems making it possible to listen to different types of music in different areas of a room at the same time.

Quality in research and innovation projects. The informants generally point out that they provide access for employing practical use-cases and models from the company into university research that they would not themselves have been able to develop. In other words, the corporations' often large R&D-departments have in many instances developed models, technology and

facilities that are not available in the university research environments. And for a practical oriented department as the one we have examined, this does constitute a big importance for creating ground-breaking research results, thus increasing the quality of research.

External funding. An informant from the interviewed research group notes that the European calls for Horizon 2020 as well as national innovation funding are shaped by industrial interests at the European level. Therefore, it is a clear advantage for the research environments to be able to draw in industrial profiles in the application-process, e.g. in order to heighten the quality of the application and draw in other relevant partners from the researcher's industrial networks.

Education – bachelors, masters and PhDs. The interviewees all point out that the employability of students is positively affected by the part-time positions. Mobility opens a more effective window for student projects in which the students can get direct access to challenges and problems defined by the companies. The mobile researchers also point out that they can bring inspiring elements into the educational activities, e.g. a car located at the department in which the students can tamper with the audio systems.

As will be discussed in section 5, the Aalborg Model of problem based learning has played an important general role as driver behind university-business collaboration and sector mobility at the university. Concurrently, sector mobile researchers have given rise to more and better student projects at the university. The students can, through the mobile researchers, be provided with more direct access to data, cases, and new cutting-edge technology that would not otherwise be available.

1.5 EFFECTS OF SECTOR MOBILITY ON THE CLUSTER

As mentioned in the introduction, the Department of Electronic Systems has played – and plays – a very important role for innovation and growth in the ICT-sector and electronics sector around Aalborg, as well as other business strongholds in the area, such as wind energy and audio. This is both in terms of research, but just as importantly, the many engineering students that graduate at the Department every year.

Recruitment of students and PhDs. Among the key effects for the companies engaging in AAU's part time mobility schemes is the opportunity to build up a more direct relationship to the students at an early stage in their career. The mobile researchers are both familiar with the talent base at the university and the internal challenges and needs of the companies, giving them an effective role as talent "matchmakers". In practical terms, the sector mobile researchers convey projects from the company to the students, where they get personal contacts at the company.

Innovation in the company. Generally, the interviewees point out that the part-time professorships at AAU have played an important role in furthering research and development in the collaborating companies. One of the most important examples is the "outgoing mobility" of the three researchers, spending 20 per cent of their time at Bang & Olufsen. During the year where the scheme has existed these researchers have been instrumental in guiding the development of new technologies at the company.

The researchers bring the newest ground-breaking research to the company in which they can apply their knowledge in practical use-cases. For example, they introduce research in perception and sound technology, which can be applied in the development of intelligent loudspeakers that can "split" up/ divide a room in(to) distinctive sound zones. Thus, enabling two people in the same room to listen to two different kinds of music.

Profiling in the market. For some of the companies, the mobile researchers can provide the company with an important branding-effect. For example, one informant pointed out, that the ability to promote products as being research-based as well as the professorships themselves have spurred much positive publicity in the press.

1.6 DRIVING FORCES BEHIND SECTOR MOBILITY

Table 1 shows our assessment of identified driviers to sector mbility and their individuals strength. The strength of the each factor is evaluated at a scale from 1-5 (1 being a weak effect on sector mobility, and 5 implies a strong effect).

Tabel 1: Driving forces behind sector mobility at AAU Department of Electronic Systems

	Assessment (1-5)	Comment
National and regional frameworks and strategies		
Government programmes to increase sector mobility	1	The Ministry of Higher Education and Science does not have programmes to enhance sector mobility.
Special career tracks	3	The universities have a number of opportunities, However, these opportunities are utilised differently between individual universities and departments.
University strategy		
General university strategy and focus on sector mobility	4	The management at AAU has been instrumental in bringing sector mobility on the strategic agenda.
Tradition and culture of sector mobility in selected departments	4	The Department of Electronic Systems has a long history of close engagement and outgoing mobility with the local business sector.
Flexible leave opportunities	2	The departments can assign researchers with leave of absence in cases where researchers wish to apply for jobs elsewhere – and do so in a few cases.
Flexible positions	4	Both ingoing and outgoing mobility is facilitated by flexible (mostly 20 percent) part-time positions.
Research profile and match with industry needs	5	Research of the departments highly matches the needs of the industry.
Other knowledge bridges		

Spinouts	2	AAU creation of spinouts is limited and there is no indication that it carries significant impact on sector mobility.
Amount of joint research projects	5	The extent of collaborative projects is high.
Business culture		
R&D-intensive cluster/sector	4	The ICT-sector of Northern and Western Jutland is strongly R&D-intensive.
Business involvement in university research	3	The regional business environment is very engaged in the research of Aalborg University.
Publication culture	4	The businesses engaged in sector mobility at the Department of Electronic has generally allowed co-publications with university-researchers.
Physical proximity	3	Proximity is stressed as important by most interview persons.
Successful sector mobility	4	

The part-time professorships were developed at the Faculty of Science and Technology. The model grew out of the existent strategic relations with large industrial companies. From the outset, the dean at the Faculty wanted to deepen the most important relations and bring them to the next level. Thus, the extensive, existing university-business collaboration with research-intensive industrial corporations in the form of joint research projects played a major role.

Another important driving force behind sector mobility at Aalborg University is the "Aalborg-model" of Problem-Based Learning. The model is in general an important driver for university-industry collaboration, as the learning model is built on real-life challenges and cases in business and society that demands researchers, students and companies to work closely together on identifying and solving problems. All the interviewees note that this, in many cases, led to industrial PhD-projects, R&D-projects and in some cases collaboration on mobile researchers, who concurrently can constitute a very effective vessel for establishing new student projects.

Thus, the environment's close collaboration with Bang & Olufsen has gradually evolved, using student and PhD-projects, in which Prof. Søren Bech played a major facilitating role. Moreover, mobile researchers give the companies a direct opportunity to tap into the talent pool of AAU, and "spot" talents, equipped with an intricate prior understanding of the company (e.g. through student projects).

Thirdly, according to the Head of Department as well as an interviewed representative of the university management, the model for part-time professorships is extremely reliant on the fact that the professors are not treated differently than other professors at the same level. Therefore, it is a critical condition that the mobile researchers are at a high level of research excellence.

Physical proximity is a driver in the case of Nokia Siemens Networks Bell Labs and the broader connection to, which is located directly at the campus.

The personal motivation factor is also emphasised as an important driving force. For the (ingoing) part-time professors, two informants pointed out that they have been strongly motivated by researching in new technology and by inspiring the new generation of students and PhD students, and that they have found it hard to combine "free" research with a full time industrial career.

According to the Head of the Department, the high research and innovation intensity of companies in the ICT-cluster of Northern Jutland play an important role in spurring sector mobility. Without a certain research and innovation level and critical mass in the companies' research departments, the 20-pct.-collaboration model is not interesting enough for the Department's researchers.

The case of the Department's collaboration with Nokia Siemens Networks (Bell Labs) is illustrated in the main report.

Case 2

DTU Departments of Wind Energy, Electrical Engineering and Applied Mathematics and Computer Science, and the energy and medtech clusters

2.1. THE UNIVERSITY AND THE REGION

The Technical University of Denmark (DTU) was founded in 1829 under the name of the Polytechnic Institute. The Institute was an initiative of Hans Ørsted, who was among the fathers of the study of electromagnetism. He was rector of the institution in 22 years.

The institution belonged to the University of Copenhagen (UCPH) until the 19th century. Its growth was closely linked to industrialisation, which entailed a growing need for engineers. In 1890 the institution moved from Studiestræde to Sølvgade, and then in the 1960s it was again relocated to Lundtoftesletten in the northern suburbs of Copenhagen. Here it was coined the "Technical Folk School of Denmark".

During the last couple of decades, DTU has increased in size. In 1995, it grew as a result of a merger with the Danish Engineering Academy (DIA). Again, in 2007, DTU merged with five sector research institutions, which further enhanced its growth. One of the institutes that became part of DTU was Risø, located near Roskilde, at which DTU still has 5-6,000 employees today. The additional sector research institutions merging with DTU included research centres of food, space, fishery and transport.

Today, DTU has 10,600 enrolled students, 5,800 employees, and a budget of 5 bn. DKK. The university consists of 22 departments. DTU has 223 professors, 436 associate professors and fellow, 359 senior researchers, 83 adjuncts, as well as a number of postdocs and PhDs.

In the Leiden ranking of technical universities DTU is number 38. The university has two Nobel prize winners: Niels Bohr (shared with UCPH, where he did most of his tenure), who made critical contributions to nuclear research and the field of quantum mechanics – and Henrik Dam, who received the award for the discovery of vitamin K.

DTU is a university specialised in training engineers and it is present in many fields of technical science. Compared to UCPH, DTU is more oriented towards applied research and less on basic research - although there much excellent basic research is carried out at the DTU. Research at the university has received several grants from the former Danish National Advanced Technology Foundation, the Danish Council for Strategic Research, the current Innovation Fund Denmark, the Danish National Research Foundation and grants under Horizon2020.

DTU is particular strong in terms of business collaboration, innovations, and spinouts. In 2015, DTU fostered 53 start-ups. Of these, approximately 50 percent were created by students, while the other half was founded by researchers. These numbers also include non-IPR based start-ups.

2.2. ABOUT THE CASE

The case-study is based on DTU's collaboration with two clusters: the cluster of energy and the cluster of hearing aids and healthtech. This include the department of Wind Energy (which collaborates with the wind industry), DTU Electrical Engineering (which collaborates with the energy industry and healthtech industry), and lastly DTU Compute, which has a close collaboration with the healthtech industry, but also cooperate with the energy industry.

Pivotal driving forces behind sector mobility between DTU Wind Energy, Electrical Engineering, and Compute and the energy- and healthtech clusters

DTU Wind Energy, Electrical Engineering and Compute	The energy- and healthtech clusters
• Tradition and culture of close business collaboration at the three departments • Tradition of high levels of sector mobility • Research profiles that match the needs of the cluster • Many spinouts and good innovation facilities	• Significant involvement of businesses in public research • Significant co-financing of research by businesses and foundations • Important proximity factors

Two of the three departments – DTU Wind Energy and DTU Compute – are relatively big. DTU Wind Energy has 150 full-time researchers (professors, associate professors, senior researchers etc.). DTU Compute employs 24 professors, 67 associate professors. DTU Electrical Engineering is smaller and has 12 professors, 39 associate professors, and 14 adjuncts.

The Danish wind cluster, which in this context acts as a relevant part of the energy sector, had in 2015 a turnover of 88 bn. DKK, an export of 48 bn. DKK, and employs 31,000 persons in Denmark. However, the majority of firms in the wind energy cluster are located in Western Denmark making. This applies to both corporate headquarters, manufacturing, and R&D departments.

The healthtech sector is harder to define, as it consists companies that mainly supply equipment and devices, and companies that provide services and solutions. Estimates of Copenhagen healthtech cluster show the cluster has a turnover of 30 bn. DKK and it has an employment of 20,000 people. Contrary to the wind industry, a large part of the Danish healthtech industry is located in Greater Copenhagen.

2.3. EXTENT OF SECTOR MOBILITY

At DTU Wind Energy 12-13 tenured researchers, out of a total of 150, have experience as researchers in the industry. DTU Electrical Engineering has approximately 15 researchers with experience as researchers in the industry, out of a total of 51 tenured researchers.

At DTU Compute 12 out of 91 tenured researchers have working experience as industrial researchers. Thus, the average number of researchers with experience as researchers in the industry in the three departments is approximately 15 percent. However, the interviewees assess that the tendency falling.

Outgoing sector mobility is also low. However, it is assessed to be at a slightly lower level than ingoing mobility. Therefore, the three heads of departments assess that outgoing mobility comprises 10 percent – and this is almost exclusive at the associate professor level. Additionally, a significant number of PhDs and postdocs are hired in industry.

2.4. EFFECTS OF SECTOR MOBILITY

Organisation and collaboration: all three interviewed researchers, who work at DTU today, in most cases fulfil a role as research director of an institute at DTU. They describe how the research culture is fundamentally different at DTU than in companies. Collaboration at DTU, both within the individual departments and between them, is strong. Nevertheless, each research group can, within wide framework conditions, define its own strategy, methods, and research topics. In companies, the level of coordination is much higher. Yet, sector mobile researchers have brought parts of the corporate culture into DTU and they seek to contribute to a higher degree of interdisciplinary coordination.

Network with the industry: sector mobile researchers have an extensive network in the industry compared to their colleagues. The three researchers we interviewed have worked as researchers at respectively GE Healthcare (*Jan Henrik Ardenkjær-Larsen*, see box), Siemens Wind Power (*Kenneth Thomsen*, DTU Wind Energy) and Oticon (*Rasmus Paulsen*, DTU Compute). Typically, researchers continue to keep a close and good cooperative relationship with their previous workplace in the industry, and these relationships are utilised in both research and teaching.

Rasmus Larsen, DTU Compute, agrees with this perspective. Yet, he also emphasises that employees who have experience of working in the industry are highly useful for the departments of the university, *"For an institution like ours that does not cooperate with a separate or total industry, but with many different companies in almost every industry, it has a special value to have a corps of ambassadors in the business community."*

Research focus: sector mobile researchers know the internal agendas of the companies as well as challenges outside DTU and in the industry, which gives them leverage to influence the research strategy of the environment.

Research method: sector mobile researchers put greater emphasis on completing research projects compared to other researchers. As an example, *Rasmus Paulsen* mentions requirement of weekly reports on projects and schemes of handling risks, which is a procedure many university researchers are unfamiliar with. Another example is lean analysis of how projects are most effectively managed.

External funding and business collaboration: sector mobile researchers find it easier to develop and formulate projects that obtain joint support compared to others. However, the sector mobile researchers also appreciate business collaboration due to other reasons than acquiring additional financing.

Education – bachelor, masters and PhDs: sector mobile researchers use examples based on their own working experiences in the teaching, and in they help facilitate contact between students and businesses. This makes teaching much more pedagogical and it furthermore gives the next generation at better network across sectors.

Continuing education: all three departments, especially DTU Wind Energy, have given greater priority to the area of continuing education the recent years. Particularly, this is a result of the three clusters' need to continuously upgrade their employees' level of competence. All three interviewed researchers emphasise that continuing education is an important knowledge bridge.

2.5. EFFECTS OF SECTOR MOBILITY ON THE CLUSTERS

As a part of the analysis, we have also interviewed to persons in management positions within the two clusters: *Gert Rode*, Director in GE Healthcare, and *Lars Martiny*, Senior Vice President in Haldor Topsoe.

Gert Rode has a PhD and hence has not himself been tenured as a university researcher. However, he contributed to the maintenance of a lasting working relationship with Jan Henrik Ardenkjær-Larsen (JHAL, see box). For GE Healthcare, contact to a researcher like JHAL is important to keep up with the highest level of research, which is essential for the competitiveness of the firm. Prioritising articles and conferences, entails crucial delays compared to competitors. A sector mobile researcher, as JHAL, is first and foremost an important gatekeeper for the firm to access relevant people at DTU - not only at JHAL's department, but at the whole of DTU.

Lars Martiny (LM) has a PhD in physics from Aarhus University. Following his graduation, for a short period he held a research position in Scotland (Glasgow) and in Paris. At the hospital Rigshospitalet in Copenhagen, he was initially hired as postdoc and later he got a tenured research position in which he primarily worked with radioactive trace elements.

In 2001, he was headhunted to Novo Nordisk where he was the only researcher with experience of working as a university researcher within his department. In 2004, he was moved to the Danish research institution Risø in order to contribute to the establishment of the so-called Hevesy Laboratory, which focused on radioactive isotopes and trace elements in medical treatment. In 2010, he became chief operating officer at Risø, and in 2011 he started working at Haldor Topsøe. Among other things, he managed a number of the firm's R&D projects. Subsequently, TM has completed an MBA.

For LM, his past at Risø (which merged with DTU in 2007, see introduction) is crucial for his ability to build collaborative projects between Haldor Topsøe and DTU in an effective manner. DTU is a crucial knowledge provider for the company through its research, direct partnerships and new

candidates. With its location, Haldor Topsøe is located a few kilometres from DTU. Its significant development department, and a total of 1.300 employees in Denmark, is entirely dependent on close knowledge collaboration with DTU. This is especially in terms of its catalytic products and chemicals used for, among other purposes, energy, food, and the materials industries. The turnover of Haldor Topsøe is of 5.5 bn. DKK annually.

In addition to LM's role as a central contact, he also perceives himself as a resource who both initiates new projects and who can critically complete and evaluate these projects. LM has achieved an overview of several research areas due to his experience as a university researcher, which is an important asset for the firm.

2.6. DRIVING FORCES BEHIND THE SECTOR MOBILITY

Table 2 shows our assessment of identified driviers to sector mbility and their individuals strength. The strength of the each factor is evaluated at a scale from 1-5 (1 being a weak effect on sector mobility, and 5 implies a strong effect).

Tabel 2: Driving forces behind sector mobility at DTU Wind Energy, DTU Electrical Engineering, DTU Compute

	Assessment (1-5)	Comment
National and regional frameworks and strategies		
Government programmes to increase sector mobility	1	The Ministry of Higher Education and Science does not have programmes to enhance sector mobility.
Special career tracks	3	The universities have a number of opportunities. However, these opportunities are utilised differently between individual universities and institutes.
University strategies		
General university strategy and focus on sector mobility	3	The management at DTU understands the importance of sector mobility but has not actively formulated a strategy.
Tradition and culture of sector mobility in selected departments	4	The three departments have a positive position towards sector mobility.
Flexible leave opportunities	2	The departments can assign researchers with leave of absence in cases where researchers wish to apply for jobs elsewhere – and do so in a few cases.
Flexible positions	1	At present, shared professorships are almost never applied at the three departments.
Research profile and match with industry needs	5	Research of the departments strongly matches the needs of the industry.
Other knowledge bridges		
Spinouts	5	DTU produces many spinouts. Spinouts are highly prioritised by the management at DTU and university departments.

Amount of joint research projects	4	The extent of collaborative projects is high.
Business culture		
R&D-intensive cluster/sector	3	Both the energy sector and healthtech sector have research at a high level of quality, although there are more emphasises on development activities.
Business involvement in university research	3	The energy – and healthtech clusters are committed to the research of the university.
Publication culture	3	Varies greatly between businesses, though some firms are relatively open-minded and allow a high publication level.
Physical proximity	4	Proximity is stressed as important by most interview persons. The importance of proximity is further enhanced by really good incubator- and innovation frameworks, such as the Scion DTU.
Successful sector mobility	4	

The national framework conditions allow universities to undertake a number of initiatives promoting sector mobility. However, Denmark does not have a national program to enhance sector mobility.

The management at DTU have a certain focus on sector mobility and they are aware of its importance. DTU has no statistics on sectoral mobility, but is aware of and appreciate that a significant number of researcher at DTU have an industrial background.

At all three selected departments, the Heads of Departments are aware of the importance of sector mobility. Thus, they have also themselves been employed in three different business for a brief period: Peter Hauge Madsen at Siemens USA, Kristian Stubkjær at IBM USA, and Rasmus Larsen at Novo Nordisk Denmark.

With regards to recruitment, Peter Hauge Madsen expresses that it may be suitable to initiate some organisational creativity to promote mobility. It is difficult for industrial researchers to publish sufficient amounts of research results to obtain a position as associate professor or professor. However, according to the rules university departments can for example employ persons as chief engineers with almost the same prestige and salary. When such persons subsequently publish, they will later be able to achieve a position as associate professor or professor if this is essential for them.

The departments grant leave of absence to employees in a limited number of cases due to economic constraints. Furthermore, there is virtually no shared professorships.

High levels of quality research at the departments has a very important impact on sector mobility – within selected sub-areas the departments are some of the best knowledge generating environments in the world.

As mentioned in the introduction, DTU displays a high spinout level, which is supported by the management of DTU, the incubator environment Scion DTU and the three departments. However, in practice only a limited number of cases have led to sector mobility at the associate professor or professor level.

On the other hand, the significant number of collaborative projects does to a high degree leverage sector mobility. The projects indicate that researchers know each other across sectors and in a number of cases it has led to recruitment to the industry without job adverts, or the like.

The mixed composition of firms, whether start-ups and SMEs at one side and big established companies on the other, also supports sector mobility. A number of the large companies have significant research and allow their researchers to publish research results. Among these are e.g. Oticon, GE Healthcare, and Siemens.

Finally, proximity has a positive effect on sector mobility. Thus, several of the interviewed researchers stress the Danish healthtech cluster's location in the capital region has a positive effect on sector mobility. Also, the Danish energy sector has a large part of its R&D entities located at Zealand.

2.7. ROLE MODELS

Box 1. Professor Jan Henrik Ardenkjær-Larsen

Jan Henrik Ardenkjær-Larsen (JHAL) has been professor at DTU Electrical Engineering at DTU since 2015. After receiving a grant from the National Research Foundation he became professor and head of Centre for Hyperpolarization in Magnetic Resonance. These are methods which open completely new ways to diagnose e.g. cancer.

JHAL started his career as electrical engineer with an industrial PhD from DTU. After he had been employed at Nycomed from 1994 to 1995, followed by a position as adjunct at DTU until 1997, he was employed as senior researcher at Nycomed. In this position, he conducted research in magnetic resonance. Nycomed merged with an English company, Amersham, which then was acquired by GE Healthcare in 2004. Subsequently, JHAL conducted research at the General Electric Global Research in NY, USA, for two years, followed by three years at Amersham in UK.

In the coming years, JHAL worked at GE in which he had home office in Denmark. JHAL has with his professorship maintained a relation with GE, whereby it works as a secondary occupation for him.

Hence, JHAL has experience of working at GE as a university professor – and later he has experience of working as a university researcher with an industry background.

JHAL notes the significant differences in the research culture between firms and universities. At university researchers have greater freedom of research, while researchers in industry are subject to tougher requirements on reporting about milestones and continuously assessment of "dead ends" and the removal hereof. Simultaneously, JHAL is for GE the key to access several persons at DTU due to his network. This besides the fact that JHAL is careful not to favour GE in any way and that he also uses other of his contacts in the industry as examples in his teaching, when facilitating contacts between business and students etc. However, he believes, consciously and unconsciously, that he has taken a more focused research culture with him into DTU.

Gert Rode, Director in GE Healtcare, confirms the opinion of JHAL; that in his case there are cultural effects both ways: from GE Healthcare to DTU and vice versa. GE Healthcare would like to have similar contacts to the university environment.

Case 3

Computing and system analytics at EPFL and the related cluster in Western Switzerland

3.1. THE UNIVERSITY AND THE REGION

Ecole Polytechnique Federale de Lausanne (EPFL) was established in 1969 when the former Department for Science and Engineering was separated from the University of Lausanne (UNIL), which it had formed part of since 1853. The establishment of EPFL as a separate, federal university was part of a strategic enhancement of the funding of research and production of university candidates in science and engineering by the Swiss government. Today, EPFL and UNIL are co-located a few kilometres outside Lausanne by the Geneva Lake. EPFL is one of two federal universities in Switzerland (together with ETH Zürich).

Since 1969, the EPFL has systematically improved its scientific production and ranking. Thus, the university is not only in competition with ETH Zürich, but a range of other technical universities globally. EPFL is now no. 92 on the Shanghai/ARWU ranking, and its latest position on the Leiden ranking is no. 146. This makes EPFL no. 3 or 4 in Switzerland after ETH Zürich and University of Geneva according to the Shanghai/ARWU ranking. In the Times Higher Educations ranking EPFL is no. 31 and no. 2 in Switzerland.

EPFL has an annual budget of 965m CHF, more than 10,000 students and 340 professors. Generally, the quality of the research infrastructure and the level of wages are high at the EPFL.

EPFL´s research activities are divided between a number of institutes, e.g. Architecture, Environmental Engineering, Electrical Engineering, Mechanical Engineering, Material Science Engineering, Microengineering, Bioengineering, Computer and Communication Sciences, Technology Management etc. There is also a section for basic sciences (Chemistry, Mathematics, and Physics) and for Life Sciences (focusing on Neuroscience and Cancer research).

The Vaud Region, in which Lausanne lies, covers approximately 10 percent of Swiss GDP. Strongholds are medtech, IT-related industries, life science, mechanical engineering, services, and finance. EPFL cooperates intensively with regional companies, but also with other Swiss companies due to its federal status. In order to strengthen its international status, EPFL also cooperates with multinational and foreign companies.

3.2. ABOUT THE CASE

Based on our general analysis framework the following table shows the specific factors that we find decisive for high sectoral mobility in the present case.

Decisive factors for a high sector mobility in two faculties at EPFL - IC and ENAC

EPFL	IT- and system analytics-related enterprises in Switzerland
• Strong general culture and tradition for cooperation with business • Special tradition for high incoming mobility in IT, communication, and engineering • Well-functioning Innovation Park • Increased government co-funding of joint research projects	• Research-intensive enterprises • Involvement in university research • Many spinouts and start-ups • Large enterprises forced to innovate due to high labour costs

EPFL has no official statistic covering in- and outgoing mobility, but our sources state that sectoral mobility has declined in the last two or three decades.

Interestingly, however, there are considerable variations in this pattern. Based on discussions with the university and enterprises, we identified a group of companies with strong ties and close cooperation to EPFL with a common trait of using *highly sophisticated computing and system analytics* related to research at two faculties at the EPFL.

One of these two faculties is ENAC. At ENAC, especially the two Institutes of Civil Engineering and Environmental Engineering are closely connected to the Swiss business sector. The have 1,255 enrolled students, a full-time staff of 420 people, and 42 full professors. ENAC also comprises the Institute for Architecture, which has a long tradition of allowing professors to work part-time (often 50 percent) while running their private practices.

The other is IC - Computer and Communication Sciences - with 1,404 students, a full-time staff of 433 people and 32 full professors.

The companies cooperating with these two faculties are not part of a formal cluster organisation but have developed over the last two or three decades. Thus, they amount at least 10 percent of Swiss GDP.

Examples encompass global IT-based companies like IBM and Cisco with Swiss affiliations, the medtech sector and companies working with spatial data (we have interviewed companies in all these categories, cf. below).

We interviewed the deputy CEO of the Chamber of Commerce in the Vaud Region, *Julien Guex*, about the nature of cooperation between the business sector and EPFL. According to Guex, the group of companies cooperating with EPFL, not in only Vaud, but all of Switzerland, is growing and strongly research-based - especially with these two faculties.

For instance, the number of jointly financed research projects in this area has increased by more than 50 per cent in the latest 10 years due to a strong increase in the co-financing of such projects offered by either the CTI (Commission de Technologie et d´Innovation) and the SNF (Swiss National Fund for Research).

The number of spinouts has also increased strongly in the last 10 years - a doubling from the level of 12-14 10 years ago to 25 in 2015. EPFL points to the fact that they have the same number of spinouts as ETH Zürich, which has a 70 percent larger budget.

3.3. EXTENT OF SECTOR MOBILITY

Incoming mobility - from industry to EPFL

According to the vice provost for research, *Andreas Mortensen*, only a minority of all researchers and full professors at the EPFL have worked as researchers in private companies. We estimate the proportion to be approximately 20 percent. Within the last 3 years, 80-90 percent of all newly recruited tenure track assistants, associate and full professors come from academia. Very few professors have been recruited to enterprises.

Sector mobility (especially *incoming mobility to professor positions)* has declined markedly in the latest 20-30 years, which according to the interviewees is the result of a much stronger academic competition for professorships than earlier. Thus, the requirement of having produced a large number of peer-reviewed, highly cited academic articles has increased in order to fulfil the criteria for being appointed as a professor.

At EPFL, the "needle eye" in a typical academic career is to get a position as tenure track assistant or associate professor. According to our interviews, more than 70-75 percent of people in these two categories reach the position of full professors. This is often without an open call if the management considers efforts and results to be satisfactory. The majority of assistant professors come from similar positions at other universities and countries abroad. Thus, only a minority of new professors have industry experience. The same applies to junior positions (postdocs etc.).

The management of EPFL has no strategy to change this pattern of reduced sector mobility. Instead, they emphasise increasing internationalisation, i.e. recruitment of "star professors" from highly ranked universities.

However, as mentioned in section 2, there is a relatively high sector mobility in the departments of ENAC (Engineering and Architecture) and at IC (Computing and Communication). In ENAC and in IC there are 162 and 80 professors (assistant, associate and tenure track professors and full professors) in total. Of these 50 and 34 are full professors.

At the IC Faculty, *incoming mobility* (seen from the perspective of the university) is high. 5 out of 10 professors recruited from private firms have during the last three years worked at least a couple of years as researchers in industry.

These include Mikhail Kapralov, Bryan Ford, Edouard Bugnion, Nisheeth Vishnoi (all assistant or associate professors) and Sabine Süsstrunk (full professor). They all have a background in multinational corporations like IBM, Microsoft, Cisco, Corbis Corporation, and Hewlett-Packard, as well as in a number of start-ups created by themselves (Sleepless Software, Phobos inc, VMware and Nuova Systems). The EPFL management stresses that incoming sector mobility at the IC Faculty is more than double the size compared to the average level of sector mobility at EPFL.

Furthermore, James Larus, who worked 16 years as a researcher in Microsoft, was appointed dean of the IC faculty in 2014.

In ENAC, 3 out of 11 recruitments of assistant and full professors during the last three years have an industrial background. This is not as impressive as the mobility at IC Faculty, yet it is above the EPFL average.

5-10 researchers with an industrial background has been hired to positions as postdocs in the same period to the two faculties. Similarly, many postdocs leave to industry during their career within academia or when their temporary positions end (all postdoc positions are temporary and connected to the duration of external funding).

Outgoing mobility - from EPFL to industry

Outgoing mobility at IC and ENAC is lower than incoming mobility. Outgoing mobility at the level of assistant and full professors has been low the last 3-5 years. No assistant and full professors at IC, and only a few assistant professors from ENAC, have left the EPFL to the industry. However, during the same period, a number of postdocs have left the two faculties to work in larger corporations and SME. This especially includes spinouts based on EPFL research results.

The two faculties are, on the other hand, very active in creating spinouts and start-ups. In the last two years 15 start-ups are created based on inventions/technology developed in the two faculties. These companies are mostly within the fields of Medtech and Computing and system analytics. Examples of medtech start-ups are Lunaphone, Morphydyne, Pristem, Spirochrome, and Syneastech. Spinouts in computing and system analytics include Anemomind, Bestmile, Flyability, Gamaya (see case description below), Impmer, Pocket Campus, and Dowzy.

Between them, the two faculties, with 15 percent of EPFL´s budget have around 30 percent of its spinouts. The majority of spinouts are located in the EPFL Innovation Park (see below).

In most of these spinouts postdocs and PhDs are recruited together with business talents to work full-time in the spinout/start-up. Assistant and full professors will normally work at the spinout for a period. Most often, this will be part-time as advisors or in boards, but rarely full-time.

Professors are allowed to work 20 percent ("one day per week") on non-university assignments. They are required to register such activities, the corresponding income, and to register if possible conflicts of interest could occur. The administration of these rules is described as "pragmatic". Hence, as long as teaching, supervisory and research demands are met the exact amount of outside work is less important. The general pattern is that most professors have some activities in consulting but the minority of professors who have been engaged in spinouts use most of their "free time" here.

Furthermore, a general rule at EPFL is that if non-university tasks become more demanding, professors can ask for a reduction in time and university obligations. According to our interviews, this occurs and requests for such arrangements are normally accepted. However, very few professors (less than 10 percent) apply for such reductions. The exception to this rule exists at the Institute of Architecture, where a majority of professors work part-time.

Assistant and full professors can ask for a leave but they have no formal rights to get a leave. According to our interviews, leaves (i.e. with right to return to the university as professor) are only granted in a minority of cases, in which it is of high importance to EPFL that a professor returns to the university. Such leaves can be granted both when professors leave for another university or to a private enterprise.

3.4. EFFECTS OF SECTOR MOBILITY

During our visit to EPFL, we interviewed research management representatives and researchers about the effect on culture, cooperation (internally and with industry), research, and education of "sector mobile researchers". We had a number of interviews focusing on EPFL, and specifically IC and ENAC. The most important effects identified are described below.

Culture, organisation, and internal cooperation: the interviewed persons stress that internal cooperation is well-functioning. However, they are uncertain about to what extent this differs from the rest of EPFL. One interview person states the culture is more oriented towards operational results rather than academic papers and processes.

Networks with industry: sector mobile researchers clearly have a positive impact. These networks are described as local/regional in relation to SMEs and start- ups, and global in relation to larger enterprises. Naturally, all mobile researchers have strong ties to companies they have worked in. But in general, mobile researchers also have more business connections, i.e. a strong network to other companies.

Research focus: research at IC is described as "practical" and "user oriented". This is both a result of the research area and a result of sector mobility. There are no cultural barriers to work for or with private partners. In ENAC, sector mobility has leveraged both cooperation with private companies and the ability to address important societal challenges; especially in the fields of healthcare, environmental issues and urban congestion. The most important impact is on the concrete way research questions are handled, which researchers with a private background often implement in a more "hands-on" manner.

External funding: in general, the EPFL receives more external funding from private foundations, enterprises and the government. Government funding has been easier to achieve during the last 10 years, as the federal government has increased the budgets of both the CTI and the SNF, partly in response to the financial crisis and partly in response to Switzerland's challenges in continuing cooperation with EU about research projects, ERC-grants and Horizon 2020[3]. These government funds are used to strengthen the effect of business-university collaboration and often the funds act as a third source in these projects that corresponds to the given percentages of other types of funding. In this way, faculties and entities who already have initiated a high number of joint research projects are encouraged to do this even more.

[3] See Euresearch (2016); Swiss participation in Horizon 2020 (web)

Industrial cooperation: IC and ENAC are very much involved in knowledge transfer and joint research projects. Representatives from industrial partners (see next session) stress that IC and ENAC are open to all kinds of cooperation. Both faculties operate with joint research projects (where businesses also bring in knowledge and often data) as well as contract research. Compared to the other faculties, IC and ENAC have little research infrastructure in the form of laboratories and unique equipment, which are possible to rent for testing or experiments. Mobile researchers seem to have a better industrial network - not only with their former companies but also with other companies.

Education – Bachelor's, Master's and PhDs: Master students have internships in companies that are often chosen by the institutes' industrial partners. PhDs at IC and ENAC often work with projects formulated by industrial partners. Candidates on all levels, especially masters and PhD level, are in very high demand from Swiss businesses and the unemployment rate is close to zero.

Master students have a mandatory internship in an enterprise. In this regard, mobile researchers have a strong role in opening doors for internships in enterprises, which are in their networks. Similarly, PhDs are typically involved in industry-related projects (this is not mandatory but normal practice). Mobile researchers have an advantage in supervising PhDs to make industry-relevant research.

3.5. EFFECTS OF SECTOR MOBILITY ON THE CLUSTER

As described in section 2, companies using IT and systems analytics are generic technologies that can be used in many sectors and for many purposes. The enterprises can be found in medtech, the ICT sector, the environmental sector etc., but also in more traditional industries.

A precise assessment can be a problem at this point (as described above), because outgoing mobility for assistant and full professors is low. It is therefore difficult to measure or describe this effect as well as to distinguish it from the effects of tradition and culture.

All our informants describe cooperation with IC and ENAC as being very good. We also interviewed a life science company which argues low sector mobility at the Life Science Faculty is due to its closed nature, which makes it difficult for external actors to engage in cooperative activities with the faculty. However, the company also points to important traits:

We interviewed *Lorenzo Granai,* director for Cisco Switzerland, which is located in EPFL´s Innovation Park. With only 60 employees, hereof five with a university researcher background at EPFL and other universities, it is one of only four similar affiliations in Europe. According to Granai, these Research and Innovation units are benchmarked (even though they to some degree research and innovate within different fields). Cisco finds the EPFL environment to be world-class and contributing significantly to the company's development. As a result, Cisco has increased the number of joint Cisco-EPFL research projects and donated a professor chair to EPFL.

Switzerland also has a strong medtech sector, and we interviewed *Nathalie Viraq*, principal scientist at Medtronic in Tolochanez close to Lausanne (see box 2 below). Virag has a background as researcher at EPFL and today she is principal scientist in Medtronic Switzerland as well as a research coordinator in Medtronic globally.

Medtronic is a global US-owned medtech company with research and production facilities in America, Europe, and Asia. Furthermore, it has more than 90.000 employees globally. Medtronic employs a number of former EPFL researchers and in this case sector mobility has contributed to Medtronics strong competitive position in the field of medtech and strengthened cooperative research projects.

Gamaya, an interesting start-up using IT- and system-analytic tools to map and analyse geo-data is described as one of the most promising start-ups from EPFL in the latest years. In general, we find that the "spinout" effect strongly affects the regional economy and to some extent it influences sector mobility.

Some of these effects are evident indirectly in the context of our analysis. Especially the high number of spinouts and the emphasis of EPFL on this matter together act as an important vehicle for sector mobility for the level of PhDs and postdoc. The involvement of professors is usually part-time but can enhance mobility to other groups, job creation, and innovation in general.

3.6. DRIVING FORCES BEHIND SECTOR MOBILITY

In table 3 the driving forces behind sector mobility at IC and ENAC are summarised. We have assessed the strength of the inidividual driving forces using a scale from 1 to 5 (with 1 as poor and 5 as strong).

Table 3: Driving forces behind sector mobility in the selected departments of IC and ENAC

	Assessment (1-5)	Comment
Nation and regional frameworks and strategies		
Government programmes to increase sector mobility	1	No specific government program
Special career tracks	2	Exist only partially. However, there is a special track for researchers over 35 years with a background as business researcher
University strategies		
General university strategy and focus on sector mobility	1	No focus
Tradition and culture for sector mobility in selected department	4	IC and ENAC have a long-standing tradition for high sectoral mobility and very good industrial relations
Flexible leave opportunities	2	Leaves are granted but not very often
Flexible positions	1	Not used in selected departments

Research profile and match with industry needs	5	High profile and a strong match
Other knowledge bridges		
Spinouts	4	EPFL has many spinouts and encourages spinouts very much, allowing staff to use time and resources on these
Amount of joint research projects	5	The amount of joint research projects is high, which supports sector mobility
Business culture		
R&D-intensive cluster/sector	4	Enterprises using IT and system analytics research are very R&D intensive
Business involvement in university research	3	Business involvement is high both in terms of economy and research
Publication culture	4	Some larger companies encourage their researchers to publish results in academic journals and to act as fellows
Physical proximity	3	Proximity is important for SMEs but not for larger companies
Successful sector mobility	4	

According to *Pascal Fua,* who is a part of the management group at IC, the main reason behind the successful sector mobility is tradition and culture. The basic rules concerning career tracks, appointment of professors etc. is the same for all faculties, but applied and used differently at IC.

However, a number of other factors are also important.

Federal rules have been set up to establish a *career track* making it easier for business researchers to apply for assistant professor positions. This level in the career is described as the "needle eye" in the career track and applicants to such positions may not be older than 35. However, as an important exception to this rule, applicants older than 35 have a leeway if they can document research activities in industry. Applicants are simply allowed to deduct one year from their age for every year they have worked as a researcher in the industry.

Spinouts are described as a very important channel to sector mobility. EPFL produces many spinouts. To spur such activities an *Innovation Park* was established on the university campus 25 years ago (in 1991). This park has proved to be a great success. It has given rooms to more than 500 enterprises in the last two decades, and presently it contains more than 160 enterprises with 1,700 employees.

The enterprises are a mixture of spinouts from the university, other start-ups, SMEs, and affiliations of multinational enterprises. Our sources state that the park has contributed significantly to regional growth. They also state that the biggest advantages of being in the park is not below-market rental rates, but rather advantages of being close to both researchers and like-minded companies, as well the flexibility of the rental contract, which allows for an easy increase in the rented area.

Some larger enterprises have introduced policies that have as effect to facilitate mobility, even though this may not be the primary reason for their establishment. Normally, privately employed researchers publish considerably fewer articles in scientific journals than university researchers. Some enterprises are, however, exceptions to this rule (see box).

Companies like IBM and Medtronic actually encourage their research staffs to publish results in scientific journals – either alone, in groups, or jointly with university researchers. These companies argue such publications strengthen a company's brand, make it easier to recruit other researchers, and inform the public about the results and abilities of the company.

Similarly, companies with close and good cooperation with the university are encouraged by EPFL to give lectures at the university. The university has more than 700 fellows and does not pay for their teaching. But the efforts of this group have also strengthened "knowledge bridges" between EPFL and the industry.

3.7. ROLE MODELS

Professor Bertrand Merminod from EPFL is highlighted as a role model in the main report. Beside him the company of Medtronic is worth of mentioning:

Box 2. Medtronic

An important partner for EPFL is Medtronic, which is the world's biggest medtech company employing 85.000 people globally. The company is listed on the NYSE and it has its operational headquarters in Minneapolis, USA. Medtronic employs 800 people in Tolochenaz a few km outside Lausanne. Medtronic is the world's largest medtech company and it has facilities in 160 countries. Its headquarters is in Minnesota, US. The company was established in 1949 and it produces a long range of products: from heart-related products to diabetes products.

Tolochenaz is one of Medtronic's most important facilities in Europe due to its close cooperation with EPFL. Currently, there are 27 researchers working at the plant. Unlike many other companies Medtronic not only accepts, but actively encourages their employees to publish in scientific journals as well as being active in research communities, conferences, etc. Some of Medtronic's researchers are lecturers at EPFL. According to Nathalie Viraq, principal scientist in Medtronics, the close cooperation between Medtronic and EPFL is partly due to the high sector mobility.

Medtronic donated a professor chair to EPFL some years ago and is doing this again now.

Medtronic has patented several results that are the outcome of joint EPFL-Medtronic research projects.

Case 4

Energy research at ETH and the energy sector in Switzerland

4.1. THE UNIVERSITY AND THE REGION

Eidgenössische Technische Hochschule, ETH, in Zürich is the biggest and most prestigious university in Switzerland. It is the highest ranked Swiss university - ranging from no. 5 in the QS World rankings, to no. 19 in the Shanghai / ARWU ranking, and no. 62 in one of the Leiden rankings. It has fostered 21 Nobel laureates (as candidates, doctors, and professors) with Albert Einstein as the most famous.

ETH was founded as first federal university in Switzerland in 1854 in a strategic move to strengthen the Swiss economy. Its federal status implies that ETH should not only work with regional enterprises in the Zürich region, but with all relevant Swiss enterprises. ETH has throughout its history had a very close and well-functioning collaboration with industrial partners in Switzerland as well as globally. Since its beginning, it has grown out of the city, in the sense that some activities are still located in central Zürich, others at a newer campus in Hönggerberg, and additional facilities are spread around the city (among others is the Energy Science Center, cf. below).

ETH had in 2015 more than 19,000 enrolled students, a total staff of 9,000 people, and 475 professors (hereof 392 full professors). The university consists of 5 faculties: Construction and Architecture, Engineering (the biggest, with 35 per cent of all students), Science and mathematics, System analytics and natural sciences and the smallest, fifth faculty for Social Sciences and management with 5 per cent of all students.

ETH has grown considerably in size during the years. In the latest decade the budget has grown from more than 1,100 m. CHF to 1,712 m. CHF in 2015. As in the 19th century, a part of the last budget increase is an attempt by the Swiss government to strengthen the position of Switzerland in the international economy.

Internationally, ETH is a popular destination for students from all over the world. ETH has relatively few exchange students (410) due to strict admission requirements, but one third are non-Swiss. Of these, most come from the EU.

Professors and people at the rector's office at ETH describe the university culture as being influenced by a German university culture. Thus, they describe the culture of the university as more "professor-managed" than EPFL, which in turn is more "top-down" or "management-driven". Still, the recruitment of new professors relies in part on collegial submissions.

ETH has always been renowned for its close cooperation with the industry. The business collaboration has never been questioned, which is evident in both research and education. Although being a federal university, its location in Northern Switzerland in Zürich indicates that cooperation is especially close with enterprises located in the Zürich region. The Canton of Zürich covers

15 percent of Swiss GDP, and the regional strongholds are manufacturing, energy, finance, and services.

4.2. ABOUT THE CASE

Based on our general analysis framework, the following table shows specific factors that we find decisive for high sector mobility in the present case.

Decisive factors for high sector mobility in energy-related activities at ETH and Switzerland

ETH , energy-related research, and teaching at Faculties for Engineering and Science	The Swiss energy sector
• Increased government co-funding of joint research projects • Generally, a strong culture and tradition of cooperation with business • Special tradition for high ingoing mobility in energy-related research	• Research-intensive enterprises • Strong involvement in university research • Large enterprises forced to innovate due to high labour costs • Like in Germany, "Energiewende" (i.e. a turnaround to energy production based on renewables rather than fossil fuels and nuclear production) is seen as both a challenge and an opportunity

ETH has no official statistic covering in- and outgoing mobility, but our sources state that sectoral mobility (like at the EPFL) has declined in the last decades.

However, in the areas of energy research, mobility is higher than within the additional fields at ETH. The reason is history and culture, whereby the rules that apply for recruitment etc. are federal and the same for all faculties. Yet, at ETH, management is described as more decentralised, giving faculties and institutes more autonomy than is the case at EPFL.

Energy-related research is not confined to a few institutes. One fifth of ETH´s 475 professors undertakes research that is related to energy in one way or another. The *Energy Science Center*, which we visited in Zürich, coordinates energy-related activities and energy-related university-business research projects. It has 60 professors as members and many of these come from the Faculty of Engineering and the Faculty of Science and Mathematics. Finally, a few of the members are from the Faculty for Construction and Engineering and the Faculty of Management, Technology and Economics.

The energy area at ETH is very broad when defined in terms of research activities. ETH is strong in construction, civil engineering, mechanical and process engineering, bioenergy, systems engineering, physics, and chemistry. All of these areas include energy-related activities.

In the private energy sector there is no cluster organisation. However, the ETH Energy Science Centre has 18 medium-sized and large business partners. Together, these 18 enterprises cover

a big part of the Swiss energy sector and they all meet a couple of times a year to discuss research questions. We visited two of them: Swissgrid in Aarau, 25 km. from Zürich, and Infras, which is a consultancy firm in Zürich

ETH has always emphasised applied research along with basic research and has a high number of patents and spinouts. In 2015, ETH filed around 100 patents and created 25 spinouts. However, within the energy area the "average" size of enterprises is big and there are fewer spinouts compared to e.g. the area of services and computing. In 2015, only 3 out of 25 spinouts were energy-related (and these three were systems- and it-related). 10-15 of the 100 patents were energy-related and, according to our interviews, often filed in collaboration with bigger enterprises.

4.3. EXTENT OF SECTOR MOBILITY

Ingoing mobility

According to Head of HR at ETH, Madeleine Luethy, presumably 15-20 percent (there is no statistics covering this issue) of researchers and tenured full professors at the whole of ETH have worked as researchers in private companies. During the last 3 years, 80 percent of all newly recruited tenure track assistants, associate and full professors (again, at the whole of ETH) come from academia. Only a few professors have been recruited to enterprises.

Thus, sector mobility (especially *incoming mobility at the professor level)* has declined during the latest 20-30 years. This is the result of a much stronger academic competition for professorships than earlier. It has increased the requirements for a large number of peer-reviewed academic articles in order to fulfil the criteria for being appointed as professor.

Like at the EPFL, the "needle eye" in a typical academic career is to achieve a position as tenure track assistant or associate professor. More than 70-75 percent of people in these categories obtain a position of full professor. However, at the ETH recruitment of new professors as well as promotions to full professorships are normally the subject of a hearing among existing professors, who have a strong influence. Most assistant professors come from similar positions at other universities - often from other countries. Thus, only a minority of new professors have industrial experience. The same applies to junior positions (postdocs etc.).

The influence of professors indicates that the culture of individual faculties and institutes does not change rapidly. Hence, faculties with high sector mobility tend to uphold and continue such culture.

The management of ETH has no formulated strategy to change the general pattern of reduced sectoral mobility. Instead, they emphasise increasing internationalisation, i.e. recruitment of "star professor" from highly ranked universities.

As mentioned in section 2, the energy area has a relatively high sector mobility. Out of 60 professors, who are members of the Energy Science Center, 15 have worked as researchers in private companies. This amounts to 25 percent, i.e. a relatively high proportion, which is not seen within other fields at ETH.

However, during the latest years *incoming mobility* (seen from the perspective of the university) has been lower than this. Estimated 15 percent, which includes researchers with a relatively short period in the private sector (1-2 years). Of course, exceptions do exist. A noteworthy example of incoming sector mobility is the case of *Ulrike Grossner,* whom we interviewed. *Ulrike Grossner* is an internationally renowned specialist in semiconductors and she has worked 10 years in ABB.

Two additional new professors in 2015 with an industrial background is *Christian Franck,* who worked two years as a researcher for ABB, and *Gabriela Hug,* who worked 1-2 years as a researcher in Hydro One, Canada.

Outgoing mobility

Outgoing mobility is low. At the level of assistant and full professors, within the field of energy, only a few professors have left ETH in the last three years. During the same period, of course, a substantial number of postdocs have left ETH - most to larger enterprises.

Generally, ETH is very active in the creation of spinouts, and in general, the management of ETH promotes the establishments of spinouts. Like at EPFL, professors can use 20 percent of their working time on activities outside the university without a decrease in pay or obligations to research, and without supervision of PhDs and teach. If, in rare circumstances, a professor will ask for a bigger reduction than 20 percent, in principle this is possible. However, outside the Institute of Architecture, at which this is normal practice, there are only a few (below five) of such professors.

Assistant and full professors can ask for a leave. They have no formal rights to get a leave and leaves are normally only granted for shorter periods of time.

4.4. EFFECTS OF SECTOR MOBILITY

During our visit to ETH, we interviewed research leaders and researchers about the effect on culture, cooperation (internally and with businesses), research, and education of sector mobile researchers. We had an interview with the head of HR services at ETH and interviewed four professors from the Faculties of Engineering and Science.

As ETH is bigger than EPFL, and the energy area is distributed across a number of institutes, it is difficult to generalise from our interviews. However, there seems to be some general traits. To compare ETH with EPFL we summarise our observations in the same seven categories:

Culture, organisation and internal cooperation: in general, internal cooperation is described as well-functioning, while being highly competitive at the same time. ETH increasingly emphasises international cooperation and recruitment of professors from the best universities in other countries - especially UK and US.

Networks with the industry: sector mobile researchers clearly have a positive effect. All interviewed professors with an industrial background still cooperate with the companies they was previously employed at. However, two of them stress that they cooperate just as well with other

companies. They describe the "industrial effect" as a combination of a comprehensive enterprise network and better knowledge of how to develop and implement collaborative projects with enterprises.

Research focus: energy research at ETH is extremely relevant to society and to the private energy sector - there is not a big distinction between the two. The challenge of "Energiwende", i.e. the impetus to replace fossil fuels and nuclear power with renewables, is a great challenge for Switzerland, for energy-consuming industries and for the energy sector. Like in other countries, energy research covers many areas: power plants, power systems, energy conversion, storage in batteries etc.

Researchers at ETH with an industrial background speak a different "research language" and they are better at monitoring groups with requirements of deliverables every month or indeed week. Mobile researchers are also faster to identify and cut off "dead ends" than traditional university researchers. Another professor describes the time horizon in mobile researchers' projects as 3-5 years, whereas classical university researchers often have projects with much longer time horizons.

External funding: in general, ETH has received increasing external funding from private foundations, enterprises and the government. Yet, this development has been evident for all faculties. Government funding has been easier to obtain during the latest 10 years as the federal government has increased its budgets of both the CTI (Commission de Technologie et d´Innovation) and the SNF (Swiss National Research Fund). It has partly been in response to the financial crisis and partly in response to Switzerland's challenges as an extremely high-cost economy.

Industrial cooperation: cooperation with the energy sector is very close. Energy companies around the world face the same challenges and competition is hard. The private sector is highly dependent on university researchers to develop new solutions and methods. At the ETH, cooperation with the private sector covers all forms collaboration: jointly financed projects, private endowment of professor chairs, cooperation about PhD projects, "privatdocents" giving lessons at universities, renting facilities at the university (labs, instruments etc.), and required results. Mobile researchers often act as "gatekeepers" for enterprises seeking collaborative opportunities with the university.

Education – bachelors, masters and PhDs: alike EPFL, master candidates at ETH have internships in companies, that are often chosen by the industrial partners of institutes. PhDs commonly research on specific problems formulated by industrial partners. Among Swiss companies there is a high demand for candidates at all levels, especially masters and PhDs, and the unemployment rate is close to zero.

During our interviews, some businesses even displayed complaints about ETH, as they perceive the university to educate too few engineers. Similarly, PhDs are typically involved in industry-related projects. Mobile researchers have an advantage in supervising PhDs to make industry-relevant research.

4.5. EFFECTS OF SECTOR MOBILITY ON THE CLUSTER

As described above, outgoing mobility (for assistant and full professors) is low. Therefore, it is difficult to measure or describe this effect, or to distinguish it from the effects of tradition and culture. All our informants describe cooperation with the university as very good.

We interviewed *Jonas Mühlenthaler (JM),* who is a leading researcher at Swissgrid. Swissgrid (SG) owns and manages the Swiss electricity grid. The company is a private, limited company with energy corporations as primary share owners together with the cantons. The company has only 400 employees, because all maintenance tasks are outsourced. SG employs approximately 20 researchers - plus another 10 researchers, who are now in managing positions. Most are PhDs but a few - like JM - has worked as assistant professors. These mobile researchers clearly influence the "research climate" in SG. They have opened the possibility to enter a high number of cooperation projects with universities. Presently, SG runs four joint research projects with ETH and two with EPFL. Most of these projects are described as successful.

During the latest years, only one researcher has returned to the university. A reason is, that universities are becoming more and more "academic", which indicates that competition for assistant (and full) professorships is increasing. In Swissgrid, researchers are allowed to publish articles, because results are rarely IP-sensitive, yet few researchers have the time to do that.

We also interviewed *Markus Maibach,* CEO of Infras, which is a consultancy firm dealing with transport and energy issues located in Zürich. Infras has 50 employees, including a few former researchers. Cooperation with ETH is described as very good due to the presence of these people, who act as "ambassadors" for and to the university.

4.6. DRIVING FORCES BEHIND SECTOR MOBILITY

Table 4 shows our assessment of identified driviers to sector mobility and their individual strength in the energy related parts of ETH. The strength of each factor is evaluated at a scale from 1-5 (1 being a weak effect on sector mobility, and 5 implies a strong effect).

Table 4: Driving forces behind sector mobility in the energy area, ETH

	Assessment (1-5)	Comment
Nation and regional frameworks and strategies		
Government programmes to increase sector mobility	1	No program exists
Special career tracks	2	Exist only partially. However, there is a special track for researchers over 35 with a record as business researcher
University strategies		
General university strategy and focus on sector mobility	2	Only limited focus

Tradition and culture of sector mobility in selected departments	4	Very strong culture
Flexible leave opportunities	2	Leaves are granted – but not very often
Flexible positions	1	Many examples within the field of architecture, but very few in other areas
Research profile and match with industry needs	5	High profile and strong match
Other knowledge bridges		
Spinouts	2	ETH has many spinouts but not within the area of energy
Amount of joint research projects	5	ETH, and the federal ministry, gives high priority to joint research projects and in the energy area this supports mobility
Business culture		
R&D-intensive cluster/sector	4	The energy sector is very R&D intensive
Business involvement in university research	4	Business involvement is high both economically and research-wise
Publication culture	4	Some big companies encourage their researchers to publish results in academic journals and to act as "privatdocents"
Physical proximity	4	Proximity is an important factor for many of ETH business partners
Successful sector mobility	4	

According to *Christian Schaffner,* director of the Energy Science Center, ETH, and especially the energy area, has a long tradition and culture for both industrial cooperation and sector mobility. The basic rules concerning career tracks, appointment of professors, etc., are the same for ETH and EPFL, but traditionally sector mobility is a bit higher in ETH.

However, a number of other factors are also important. The most important of these are described below.

As we also explained in the EPFL case, federal rules have been set up to establish a *career track* making it easier for business researchers to apply for a position as assistant professor. This level at the career trap is described as the "needle eye" in career tracks and applicants to such positions may not be older than 35 years old. As an important exception to this rule, applicants older than 35 years have a leeway if they can document research activities in the industry. Applicants are allowed to deduct one year from their age for every year they have worked as a researcher in the industry. The interviewed manager from HR division at ETH states this is a rule that has had an important "signalling effect" for not only applications but the research community in general.

Some larger enterprises have introduced policies that helps to facilitate mobility, even though this may not be the primary reason for establishment of the rules. Normally, privately employed researchers publish considerably fewer articles in scientific journals than university researchers. However, some enterprises are an exception to this rule. An enterprise as Swissgrid makes it

possible for its researchers to publish in scientific journals. Enterprises, like ABB, have donated professor chairs that have paved the way for enterprise researchers to apply for professor positions.

Similarly, companies with close and well-functioning cooperation with the university are encouraged by EPFL to give ad-hoc lectures at the university. The university has more than 700 “privatdocents” and does not pay for their teaching. But the efforts of this group have also strengthened the knowledge bridges between EPFL and the industry.

Prof. Ulrikke Grossner is highlighted as a role model in the main report.

Case 5

KIT´s Industry on Campus and the ICT-sector of Baden-Württemberg

5.1. THE UNIVERSITY AND THE REGION

The Karlsruhe Institute of Technology (KIT) is among the most prestigious and advanced technical universities in Germany, as well as one of the largest research facilities of Germany.

The main campus of the KIT is located adjacent to the centre of Karlsruhe. The campus has an imposing presence in this mid-sized city in the economically vibrant state of Baden-Württemberg. The enrolment of students amounts to approx. 25,000, while the KIT has a staff of around 9,200 employees. The annual budget of the KIT is 850m EUR, of which approximately 1/3 comes from industry.

KIT dates back to 1825, where the then University of Karlsruhe was founded. The current configuration of KIT came into being in 2009 as a merger between the university and the Karlsruhe Research Center. The latter was a so-called "Helmholtz" research centre, focused on provident, applied research and technology transfer, conducting program-oriented research on behalf of the federal government[4].

The KIT of today is a world class technical university that performs strongly on many international rankings[5]. The institution is known for its world-class competencies in areas such as nuclear energy, particle physics and not least computer science. A computer laboratory was founded at the university as early as 1966, the department of informatics was established three years later and in 1984, the KIT received the first email in the world sent from the United States to another country.

In 2014, Karlsruhe received a fourth place among European ICT-hubs by the European Commission, behind significantly larger metropolises (Paris, London and Munich). The city is one of the largest and oldest locations of Siemens, while the headquarter of SAP, one of Europe's largest software companies, is situated 40 km outside Karlsruhe. The city also hosts the "Forschungszentrum Informatik" (FZI) – a KIT-affiliated applied research centre for information technology, as well as 14 other specialized research institutions that plays an important role in furthering sector mobility between the KIT and industry.

[4] Today the entire KIT has inherited status of a Helmholtz-institution. There are in total 18 members of the Helmholtz Association of German Research Centers.

[5] On the Leiden CWTS-ranking the KIT ranks as no. 4 in Europe within psychical sciences and engineering.

5.2. ABOUT THE CASE

Based on our general analysis framework, below the specific factors we find decisive for a high sectoral mobility in the present case are described.

Decisive factors for a high sector mobility in the energy-related activities at the KIT

KIT – shared instruments and KSRI Industry-on-campus environment	ICT sector in Baden Württemberg
• Well-renowned technical university with strong and long-standing links (through joint R&D-projects, PhDs etc.) to large German industrial corporations. • Long-standing trust-based relations between specific companies and research environments. • Merger between the University of Karlsruhe and the "Helmholtz" Karlsruhe Research Center in 2009, which led to an institutional strategy focused on harvesting the synergies, by bridging the cultures of the two institutions. • Innovative models for bringing industry onto campus. • Special instrument designed at the KIT with federal (Excellence) co-funding. • Strong life-cycle oriented ecosystem in Karlsruhe supporting research-based entrepreneurship.	• Large research-intensive German corporations exposed to intense disruption from industry 4.0 technologies, e.g. within digitalization, automation, and servitization. • Desire to tap more directly into university research than through traditional R&D projects. • "War on talents" – easier access to tap into university talent pool and competencies, as well as gaining access to influencing curricula and the students themselves.

KIT has for some years been promoting sector mobility at the university level. In the first Excellence Initiative[6] in 2006, the university won a funding line based on its Institutional Strategy "Foundation of KIT" – a strategy that leveraged the institutional merger.

As part of the strategy, a scheme for shared professors and shared research groups was established to enhance business collaboration and outgoing sector mobility. The scheme was partly funded by the Excellence initiative, partly by large German industrial corporations. These positions have been a major success, although there is not currently being established any new shared professorship.

Currently, the KIT primarily works with sector mobility in the shape of powerful, interdisciplinary research environments, co-funded by industry, which constitutes a framework around sector mobility. The *Karlsruhe Service Research Institute*, a so-called industry-on-campus established in

[6] The Federal German Excellence Initiative is a competitive funding scheme that aims to promote top-level research and to improve the quality of German universities and research institutions. A total of 2,7 billion Euros have been distributed through the initiative in a number of consecutive funding lines. The KIT received funding from the initiative in 2006 based on the institutional merger strategy "A Concept for the Future of the University of Karlsruhe", which led to the foundation of the KIT.

2008, stands out as a best practice case on how to create a strong, interdisciplinary setting in which sector mobility is facilitated. The Institute work with interdisciplinary research and education in the digital transformation of services.

The Karlsruhe Service Research Institute (KSRI) was founded as a public-private partnership between KIT and IBM, Germany in 2008. Today, the partnership also includes the large German corporation Bosch, as well as the Forschungszentrum Informatik (FZI).

KSRI focusses on interdisciplinary research to support and advance the digital transformation of the service domain, i.e. the innovation of services in the context of digital industry 4.0-technologies that in these years are revolutionizing the face and potentials of services – e.g. through big data analytics, artificial intelligence and internet of things. Technologies that allow for more tailored, autonomous and smart service concepts, a much more direct link to the end-user and new and vast capabilities for gaining and analyzing information about the user, which can be utilized in the innovation of new and improved products and services.

The institute itself rests on an "industry-on-campus" model for combining ingoing and outgoing sector mobility. The institute is physically located at the South Campus in Karlsruhe. At KSRI, researchers from both IBM and Bosch work together with KIT-researchers on the digital transformation of services in an interdisciplinary setting, drawing on disciplines such as computer science, management science, engineering and economics. The environment is partly co-funded by industry and led by senior researchers, many of whom are sector mobile researchers themselves with a background in industry.

KSRI transcends faculty boundaries and acts as an autonomous unit within the KIT. In terms of organization, the KSRI is divided in nine topic-specific research groups. Some of these are led by either "mobile" researchers with industrial experience or researchers with concurrent employment at IBM or Bosch. The box illustrates some of the research environments and their leading senior researchers:

Box 3. Research groups in the Karlsruhe Service Research Institute

Service Innovation & Management explores conceptual designs and implementation of new forms of services in a direct partnership between KIT and IBM. The group is led by Prof. Dr. Gerhard Satzger who is at the same time Director of Business Performance Services Europe at IBM Deutschland and Honorary Professor at the KIT. Prof. Dr. Satzger has a long background of shifting between academia and the private sector as a researcher and manager at IBM Germany.

Information Systems & Service Design which conducts research on the understanding and design of intelligent, user-centered digital service systems for enterprises and society. The research is highly interdisciplinary and includes design research, as well as behavioural science. The group is led by Prof. Dr. Alexander Mädche. Prof. Mädche has a background as a researcher at the FZI within computer science and informatics. Before becoming a professor at the KIT, he was academic director at the University of Mannheim and has a background as researcher and manager at SAP.

Knowledge Management focuses on semantic knowledge representation (used in artificial intelligence), knowledge management (how to control the flow of knowledge in a large organization) and the development of digital services. Among the leading researchers is Prof. Dr. York Sure-Vetter that has a former career as senior researcher at SAP and as president of the GESIS Leibniz Institute for the Social Sciences, where he utilized his computer science experience in a social science context.

Moreover, the KSRI serves as a platform for fostering a new talent pool with knowledge on digital service transformation. The institute offers a Master's specialisation in digital service systems, aimed at engineering students looking for a career as a service professional. The programme features in-depth modules, e.g. "digital service system in industry", "service design" and "service computing" that makes it possible to tailor a major or minor specialization. Many of the modules draw on existing courses at the KIT.

The mobile researchers actively engage the students on their future careers choices and utilize their industrial experience to guide the students' choice of modules. In a newly launched project module, students are furthermore invited to carry out projects payed for by industry, where the income is used for a study trip to Stanford University.

"Traditionally, industry would sponsor a professorship or a project, and until deadline the researcher and company would work relatively separate. That does not create the same direct connection to research results. At the KSRI, people from IBM are working together with researchers at the KIT whereby they get a direct connection to the capabilities of the environment."

Prof. Dr. Gerhard Satzger, Director Business Performance Services Europe at IBM and Honorary Professor at the KIT.

Evaluations of the KSRI have until now documented that the institute has been highly successful in terms of fulfilling the initial goals of IBM to join the partnership. IBM has consecutively prolonged their engagement and is currently committed to the institute until 2018.

5.3. EXTENT OF SECTOR MOBILITY

The KSRI is an environment that primarily furthers ingoing mobility to the KIT. There are five KIT-researchers with an industrial background and ten researchers employed by industry out of a total of 45 researchers. All examples of sector mobile researchers at the KSRI comes from large research-intensive German cooperation, e.g. SAP, IBM and Bosch.

With respect to outgoing mobility, there are a total of 13 shared research groups and 6 shared professorships at the KIT. There has not been established any new shared research groups or professorships during the last year as the funding line has expired. There is currently only one shared research group and one shared professor active at the university.

There are no official statistics covering the total extent of senior researchers with an industrial background at the KIT. And Dr. Schmuker, director of the KIT Business Club, notes that in engineering science mobility is generally welcomed. Based on our talks with the research office at KIT, the known cases are relatively few and concentrated in highly profiled, strategic environments such as the KSRI.

From our interviews with the researchers, the research office at the KIT and the KIT Business Club, there appear to be a limited outgoing mobility to industry at the senior level. The mobile researchers are typically going into industry, during their "habilitation" because of insecure prospects of getting a permanent research position at the university. However, most of these researchers rarely return to the research environments – and the examples we have, had a relative

large publication list before their industrial career, which meant that they could "start off" from a strong publication basis.

5.4. EFFECTS OF SECTOR MOBILITY

The effects of sector mobility, emphasized by the interviewees at the KSRI, as well as the shared researchers we have interviewed in other ICT-related research environments at the KIT, generally follow the same basic lines. Compared to other forms of university-business collaboration (e.g. traditional research and innovation projects), sector mobility furthers a stronger, more intimate relation bridging between academia and the industrial partners – embedded in persons that are familiar with working in "two worlds". This "two-world-knowledge" provides among other things the researcher and the environment with;

Increased personal confidence. Two of the interview researchers pointed out that mobility has increased their knowledge about their own strength, and that they could have success in two different contexts. This, and the practical knowledge they achieved, created a sense of confidence that today spills over into a strong ability to guide research projects.

"I think I understand different worlds. I have worked with "pure" research, applied research and been in industry. That provides me with a good overview of the interplay between these worlds. And It gives me confidence in my decisions and hopefully, it makes me a better leader".

Prof. Dr. Sure-Vetter, Head of research group Web Science and Knowledge Management, director at KSRI and former senior researcher at SAP

More structured research leadership. The mobile researchers at KIT have for the most part been put in positions in industry, where they had some degree of managerial responsibility, either presiding over a group or in top management positions. Industrial management skills, consisting of clear time tables, deliverables, deadlines etc., is different than typical, more autonomous research management. One researcher points out that it has led to more structured PhD-courses.

"I have experienced that I can use my industrial skills to govern people through their PhD-projects. I can provide a structured setting with deliverables, deadlines, reflections on the process, and so on. It is typical stuff you do in industry – I try to transfer it to the environment at KIT".

Prof. Dr. Alexander Mädche, head of Information Systems & Service Design, KSRI, and former Vice President at SAP.

"A professor who has been in industry, knows what industry want, and with clear milestones, project management, budget calculation etc. You know how important this is. If you only have worked at universities, you don't necessarily know how to do this."

Dr. Schmuker, KIT Business Club

Research focus The majority of interviewed researchers emphasize the ability to identify the dimensions of a research topic, which is relevant for industry/society, thereby increasing their ability to attract private funding, to tune projects in line with societal needs, and identifying issues and results that might be relevant for industrial partners.

" Whenever there is a research question we ask: what can this be used for? We ask questions focused on relevance. And I teach the students how they can transform the knowledge so that

they can talk to a product manager in a company and tell him that this could be used in his work".

Prof. Orestis Terzidis, chair of the Institute for Entrepreneurship, Technology Management and Innovation and former application developer for SAP

Increased relevance in educational activities: The mobile researchers have a first-hand knowledge/experience on practical challenges of industry and how the inner organizational workings of the company function, which gives the researchers access to cases, data and story-telling that can be employed directly in courses and seminars. Furthermore, the researchers act as gatekeepers for student projects, linking the students up with relevant people in their industrial network.

We have seminar with students, where things are very hands on. The PhDs gets to talk to employees at Bayer, use their data and show Bayer the results that they have found. It is a strong reference for both the students and research vis-à-vis other companies".

Prof. Dr. Thomas Setzer, Head of shared research group with Bayer

Increased interdisciplinarity: All the interviewed researchers at the KIT are engaged in cross-disciplinary research activities that bridge technical science with social science and/or humanities. All the mobile researchers have an industrial perspective that is relatively unaffected by classic academic silos. Instead they look at the challenge and draw in the necessary academic skills to address it.

Increased openness to risk and entrepreneurship. The researchers that have work with or in industry point out that they have a more open attitude towards failure and risk than their peers, who tend to emphasize traditional academic rigor in their research and education. The mobile researchers know from industry that competition in a company demand risk-taking and the possibility of failure. This entails that the researchers bring a more entrepreneurial culture to the research environments and in education. An example is Prof. Orestis Terzidis, chair of the Institute for Entrepreneurship, Technology Management and Innovation and former application developer for SAP. Prof. Terzedis runs courses and accelerator programmes that stimulate business start-ups (see section 7).

External funding: All interviewed researchers at the KIT notes that their industrial network and experience constitute an advantage in relation to attraction of external funding. The researchers play an important role in focusing applications, and they can use their broad industrial network to draw in partners and co-founders to collaborative R&D-projects.

5.5. EFFECTS OF SECTOR MOBILITY ON THE CLUSTER

On the company side, it is not so much the direct tangible effects (e.g. product innovation) which are stressed by the interviewees. Rather, it is the mobile researchers' role as door openers to university research and not least talents (PhDs and master students) that carries the most weight. This happens in several ways;

Talent attraction and employability. Mobile researchers can assist their companies in their recruitment strategies by pinpointing interesting environments, researchers, PhDs and students, thereby functioning as a door opener to talent.

Mobile researchers can serve as "recruitment agents" by exposing students for new technologies, practical challenges and business insights from their industrial partners/network that can prompt them to seek an employment in that business later. They can also introduce people from their industrial network into educational activities at the university, thereby fostering one-to-one contacts with students.

Thirdly, in the case of the KSRI, this goes even further. The sector mobile researchers prepare the students for specific industrial careers (e.g. data scientists), and guide them in their selection of courses. At the same time, the industrial researchers get a say in the curricula of the institute, thereby focusing the competency profiles of the students to fit the demands of the company.

"We are able to influence the topics that the students are thought in, and eventually attract people to IBM by showing them the company. In the meantime, we have developed a curriculum about IT-based services that cover an entire Master's programme. We can guide the students in their choice of modules in tune with their career desires. If the student wants to be a data scientist, we recommend that they choose module X, Y and Z. If they want to be an IP service manager we would recommend A, B and C. This resonates very well with the students."

Prof. Dr. Gerhard Satzger, IBM and KSRI.

More direct access to research environments. The IBM representative at the KSRI point out, that sector mobility gives a much more direct access to the KIT research environments than would have been the case through traditional collaborative R&D-projects. By working closely together at the campus, researchers from both sides build up trust to each other and are more willing to open up for their knowledge. This can be leveraged to enhance the knowledge exchange to and from KITs research environments.

Finally, a few of the interviewees also point to a number of tangible effects on the companies from sector mobility;

- In the shared research group of Prof. Setzer, the group have developed business intelligence systems, which are crucial for improved business forecasting and the development of new service concepts for Bayer.
- Prof. Dr. Lanza's shared professorship with Daimler had a direct importance on the global production strategies of the car manufacturer Daimler.

5.6. DRIVING FORCES BEHIND SECTOR MOBILITY

According to the interviewees, sector mobility at the KSRI can be attributed to a number of factors.

As a well-established, leading German technical university, KIT has a long tradition for collaborating closely with large corporations in the German industry as well as longstanding industrial

links. This includes corporations such as Siemens, Bosch etc. Thus, there is a general culture of mutual dependency and thrust between the large firms and KIT's research environments.

This originally led to the establishment of the KSRI. The novel, innovative model for "industry-on-campus", represented by the KSRI, enables ingoing sector mobility in an environment where researchers/developers from industry and the KIT sit physically together and work on R&D-projects of mutual interest.

Another similar example is the Institute for Entrepreneurship, Technology Management and Innovation (EnTechnon), where a senior researcher with industrial background (Prof. Orestis Terzedis – see role models) in Head of an environment focusing on harnessing the entrepreneurial potential of students. The case of the KSRI and other environments at the KIT shows that such "unorthodox", industrial related research environments constitute an attractive backdrop for recruiting and retaining researchers with a prior industrial background.

On the industry side, the interviewees point out that an important impetus is the urge to stay competitive and at the technological forefront in the context of a globalized economy and new technological and business related trends, e.g. industry 4.0, servitization etc. "Mobile" researchers provide a more direct and un-bureaucratic access to the newest research results and not least the ability to tap into the talent pool of PhDs and master students in the research environment. Specifically, concerning IBMs engagement in the KSRI, Prof. Gerhard Satzger point out four main drivers;

- Position IBM as a digital transformation leader.
- Spearhead innovation with clients.
- Build IBM-relevant service capabilities.
- Position IBM as an attractive employer.

With respect to *outgoing mobility*, the strategic aims on university-business collaboration of the KIT leadership have played a proactive role in promoting sector mobility throughout the last decade.

The merger in 2009 between the University of Karlsruhe and the applied science-oriented Forschungszentrum Karlsruhe into KIT led to initiatives aimed at harvesting the research potentials of the merger and bridging environments from the formerly separated entities. This includes the shared instruments (see box 4). These shared researchers have not been used in the context of the KSRI, but have been used in many other different research areas, some of which have strong linkages to the KSRI (see box 4).

Box 4. Shared instruments in connection with the institutional merger of KIT and FZI

The KIT Shared Instruments are flexible models for sector mobility developed at the KIT for furthering outgoing mobility, industrial collaboration and knowledge transfer, while retaining the researchers' anchoring in the research environment.

The shared instruments were envisaged in conjunction with the fusion between KIT and FZI to foster interdisciplinary research groups and bridging the two formerly separate institutions. The funds came from the Excellence Initiative based on the then institutional strategy of the KIT

The instruments allowed for a researcher, or an entire research group, to be partly funded by industry, partly by the KIT. The shared professorships and research groups have been tailored in different ways, depending on the specific collaboration and the interests of the industrial partner.

Some shared professors are in practice spending all their time leading a research environment at the KIT, working without much interference from the funding industrial partner. Typically, the company provides a degree of access to company data, technology or test facilities for the researchers. The primary function is to support an interesting research environment/researcher whose activities and results are deemed to be valuable – or potentially valuable – for the company. In these case, the actual mobility is very limited.

Other shared professors/groups spend a share of their time in the company (and is formally employed in the company), while leading a research environment at the KIT. In these cases, the researcher is actively engaged in the R&D-processes of the company, and spends around 50 per cent of the time physically at the company.

Shared Research Groups (SRGs)

The purpose of SRGs is to provide scientists with independence in their research and experiences in research management. This instrument also served as a mean of giving additional weight to the competence in research of KIT and to open new fields of research. A SRG comprise of the group leader, additional positions for scientific and technical personnel as well as consumables and small equipment. Shared Research Groups has the additional advantage of close, institutionalized connections to an industry partner or a non-university research institution. The respective partner agreed to cover at least 50% of the costs of the SRG. In total, there has been 13 shared research groups, of which one is still active.

Shared Professorships (SPs)

SPs serves as a mean of career advancement of scientists. They offered the possibility to closely collaborate with industry and allow for transfer of knowledge from the field of science to industry. Through parallel or sequential activity at KIT and an industrial partner, scientists had the opportunity to reach a decision on their future career paths. A SPs comprised the professorship as well as consumables and small equipment; the industry partner took over at least 50% of the costs. Six shared professorships have been established at the KIT, while one is still active.

This driver of sector mobility at the KIT is also manifest in the university's strong focus on commercialization of its research, which is closely linked to other actors in Karlsruhe.

KIT has strategically established an organizational structure to support university-business collaboration and spinouts. This includes the KIT Business Club – a networking organization targeted at embedding strong, strategic long term business relations to German industrial corporations and furthering technology transfer. (see box 5).

Box 5. Karlsruhe's ecosystem for research-based start-ups

IPR-based technology transfer and commercialisation at the KIT/Karlsruhe is based on a coherent model with a clear value-chain oriented division of labour between the KIT and other actors, as well as ample funding in critical stages of the maturity process.

- At the KIT, the **Innovation Management** division handles the initial technology scouting in the research environments, patenting as well as the screening of the inventions' commercial potential. The division also assist with prototype-development, feasibility and market studies and matchmaking with industrial partners.
- To strengthen the technology transfer, KIT's internal **Innovation Fund** facilitates **technology transfer projects** for the development and transfer of research results to industry. The joint work is carried out under a co-financed, collaboration with industry, featuring a license agreement. In the first phase the researcher, together with the company, develop the idea, research results or technology to a market-ready product or process. In the second phase, the product is marketed by the company and the success in the market determines the returns. The Innovation Fund is financed by returns from royalties from existing KIT-IPR.
- **KIT Business Club** is a network organisation that has the purpose of furthering knowledge- and technology transfer to industry. The Business Club has existed for 8 years, based on the notion that successful technology transfer is often based on trust-based personal relations between research and industry. The club is an attempt to ensure continuity and stability in KITs strategic industrial relations, by offering network and information events. For example, the Club hosts events with subjects that are of interest to as many companies as possible, and which is worked on by at least four institutes at the KIT e.g. additive manufacturing, industry 4.0 etc.

  Furthermore, the Club serves as a one-point entry for both researchers and company representatives looking for partnerships. The KIT Business Club works to ensure that it is up-to-date with new scientific breakthroughs or inventions that could be of interest to its member companies – as well as keeping an eye on new developments in the member companies, e.g. organizational changes, new strategies etc.

  The KIT Business Club also provides member with more than access to a "database" of results, technology etc. The organization works together with the transfer office in screening the research environments for interesting technologies and provides shortlists of research aimed at the specific member company.
- **The CyberForum** is Karlsruhe's ICT-cluster organisation and the largest in the field in Germany. The organisation has over 1,100 members and supports high-tech companies in their entire life cycle with a wide range of services. For start-ups, the services are focused on providing advice for founders on subsidies, business plans and network. For high-growth start-ups, the organisation helps with financing know-how and sales experience as well as matching the companies up with experienced entrepreneurs that can serve as mentors or customers. The cluster organisation also offer network to business angles and a business incubator (CyberLab), with office space and mentoring.

In table 5 the analysed driving forces behind sector mobility in the KSRI is summarised. We have tried to assess the strength of the inidividual driving forces using a scale from 1 to 5 (with 1 as poor and 5 as excellent).

Table 5: Driving forces behind sector mobility at the KIT

	Assessment (1-5)	Comment
National and regional frameworks and strategies		
Government programmes to increase sector mobility	2	Excellence funding for shared instruments. Not important with regards to sector mobility in the KSRI.
Special career tracks	3	Shared instruments has been used to avoid the German principle of "Hausberufungsverbot". Some mobile researchers are given responsibility of "special", cross-disciplinary environments, e.g. focused on entrepreneurship.
University Strategies		
General university strategy and focus on sector mobility		
Tradition and culture of sector mobility in selected departments	5	Culture and research profile conducive to university-business collaboration and entrepreneurship, especially at the FZI.
Flexible leave opportunities	2	Leaves can be granted if the professor has a permanent position, but it is not easy.
Flexible position	5	Shared instruments have been an important driver of outgoing sector mobility. In the case of KSRI a few research groups are entirely funded by industry.
Research profile and match with industry needs	5	KIT research profile is strongly in line with German industrial needs. The university actively encourage "matching", e.g. through the KIT Business Club.
Other knowledge bridges		
Spinouts	3	KIT produce many spinouts, but it is not particularly important for sector mobility.
Amount of joint research projects	4	Sector mobility has in most cases been initiated on the basis on a strong record of joint R&D-projects.
Business culture		
R&D-intensive cluster / sector	5	Very R&D-intensive global companies.
Business involvement in university research	5	Business involvement is high – both economically and research-wise
Publication culture	5	The R&D-departments of the large German research intensive companies do in many case encourage publication activities with university research.
Physical proximity	4	A major driver for successful sector mobility in the case of KSRI.
Successful sector mobility	4	Very successful particular cases. The shared instruments are currently not continued, and overall it is unclear what the extent of sector mobility overall is at KIT.

5.7. ROLE MODELS

In the main report, the cases of the KSRI and Prof. Dr. Gisela Lanza is highlighted. In addition to these cases, two other interesting role models is worth mentioning;

Box 6. Shared Research Group – "Corporate Services and Systems".

Prof. Dr. Thomas Setzer is head of the shared research group "Corporate Services and Systems" – a partnership between KIT Institute of Information Systems and Marketing, the FZI and the German pharmaceutical giant, Bayer. The group consists of 6 PhDs. The research group is 50 per cent funded by Bayer, and the rest by the German Exzellenz-initiative. Physically the researchers are anchored at the FZI but spends much time in and around the financial department of Bayer. Prof. Setzer's employment is temporary, running from 2011 to 2017.

Prior to this position, Thomas worked as Habilitand (post-doctoral researcher) in the field of IT Service Operations Management at Technische Universität München (TUM) in collaboration with Siemens. He received his Dr. rer. nat. in Information Systems from the Technische Universität München (TUM), and his Dipl.-Wi.-Ing. in Business Engineering from Karlsruhe Institute of Technology (KIT). He has worked as a consultant and engineer for organizations such as the European Parliament and Lufthansa, and as Visiting Scientist at IBM Research in New York.

Prof. Setzer's research group focuses on the design of management information systems and business analytics in where complexity and uncertainty is high. In doing this, Prof. Setzer's group employs big data analytics, e.g. data mining, advanced methods for pattern- and anomaly detection combined with methods from psychology and behavioral economics. The research has e.g. been used to optimize business forecasts, sales strategies and service concepts at Bayer and elsewhere.

Prof. Setzer is also responsible for lectures and seminars, presenting students for data and cases from the companies, as well as inviting employees from Bayer in the educational activities. The employees are furthermore introduced to PhD-students, their methods and techniques and possible applications in a Bayer context. Furthermore, the group has made several co-publications and conference proceedings with employees at Bayer.

"You need a long-term trust-based commitment with a company, where they understand what freedom and independence of research means. We have a 50-year relationship with Bayer. They don't expect us to do things that is away from research. They have people who do the last part of the programming internally in the company. We make research where there is a mutual interest, but we publish everything".

Prof. Dr. Thomas Setzer.

Box 7. Simulating and promoting entrepreneurship - Prof. Dr. Orestis Terzedis

Prof. Dr. Orestis Terzedis is Head of the Institute for Entrepreneurship, Technology Management and Innovation (EnTechnon). After earning his PhD in physics at the KIT, he worked during the period 1998-2011 for SAP, first as an application developer and later as the director of the SAP research centre in Karlsruhe.

He returned to KIT as a full professor in 2011, when KIT were looking for a head of EnTechnon. The person had to be employed as full professor at the institute, rather than external lectures whose affiliation to the institute would be more sporadic.

The institute is a special cross-faculty, interdisciplinary environment that conducts research in entrepreneurship. Furthermore, the institute offers educational courses for groups of engineering-students at the KIT, which gives the students the opportunity to simulate company start-up, based on KIT-IPR.

The students are working with business plans, sales strategies and entrepreneurial leadership. They furthermore must finalize an application to the German Exist-programme, aimed at research based entrepreneurship. The exam takes place as a pitch in front of actual investors of venture capital.

For PhDs and researchers with a business idea with special potentials he furthermore leads an accelerator programme for research-based entrepreneurs with more intensive supervision and feedback. Once an entrepreneur has reached a certain stage of maturity, he leads them on to other actors in the ecosystem, e.g. CyberForum.

On what made him make the shift to academia, Prof. Terzedis says;

"I was drawn by the freedom of university. It fulfils me. It was also an important motivation that I had seen a lot and I wanted to bring that back to the young generation and engagement with my knowledge. Probably not every university would have been interesting. KIT is an open-minded university, which are not afraid of engaging with business".

Case 6

Department of Pharmacy at UCPH and the Life Science Cluster

6.1. THE UNIVERSITY AND THE REGION

The University of Copenhagen (UCPH) was established in 1479 and is one of the oldest universities in Northern Europe. In Denmark, UCPH is the largest university with 40,000 enrolled students and more than 9,000 employees. UCPH is a wide-ranging university with many faculties and subjects of knowledge. During recent decades, the university has merged with, among others, Faculty of Pharmaceutical Sciences and The Royal Veterinary and Agricultural University causing the UCPH to increase in size. In 2015, the budget of UCPH amounted 8,4 bn. DKK.

Currently, UPCH has six faculties Law, Theology, Science, Health and Medical Sciences, Humanities and Social Science. At the end of 2015, UCPH had 837 professors, 1,557 associate professors, 342 lecturers, and 1,041 postdocs.

Following the University Act of 2003 and UCPH's performance contract with the Ministry of Higher Education and Science, the university is now based on three pillars, including scientific research, teaching and "dissemination" of research, in which dissemination acts as the most recent initiative. UCPH has for several decades continuously developed its dissemination with increasing emphasis on business cooperation at various levels, among others: joint research projects, contract research, industrial PhDs, and spinouts.

UCPH is highly ranked in a number of international rankings. One example is UCPH's ranking in the Shanghai/ARWU ranking list in which it is number 30 as the best university in the Nordic Countries. In the Leiden rankings the UCPH is number 30. In all, UCPH has nine Nobel prize winners.

6.2. ABOUT THE CASE

The UCPH case study focuses on the Department of Pharmacy (DP) and the Danish life science cluster headquartered in Greater Copenhagen. The reason for this choice was the close business collaboration between the cluster and DP compared to other institutes at UCPH.

The Department of Pharmacy covers a large part – but not all - of the formerly independent Royal Danish School of Pharmacy. After its merger with UCPH in 2007, it became a part of the UCPH Faculty of Pharmaceutical Sciences. Today, DP, together with other pharmaceutical departments at the Faculty of Health and Medical Sciences and the Department of Drug Design and Pharmacology, trains pharmacists to the life science industry, pharmacies and the public sector including universities.

Below, we assess drivers that have important impact on sector mobility between DP and the life science cluster.

Critical drivers to sector mobility between DP and the life science cluster

DP, UCPH	The life science cluster
• Tradition and culture of close business collaboration at DP • Tradition of high sector mobility • Research profile that matches the need of the cluster	• Firms with prominent research levels • Significant involvement of businesses in public research • Significant co-financing of research by businesses and foundations • Important proximity factors

UCPH DP is not a large institute. It consists of five sections: Section of Analytical Biosciences, Section of Pharmaceutical Design and Drug Delivery, Section of Biologics, Section of Pharmaceutical Technology and Engineering and lastly the Section of Social and Clinical Pharmacy. DP has 11 professors, 28 associate professors and 13 assistant professors, as well as a considerable number of postdocs, PhDs, other types of employees and visiting lecturers.

In regards to the Danish life science cluster it is powerful and has a significant impact on the Danish economy. It has 40,000 employees and gives rise to an overall employment of 90,000 persons when you include subcontractors etc. Of these employees, more than 10,000 are researchers.

The cluster exports for approximately 100 bn. DKK annually and is international. The Danish companies of the cluster have employees and branch offices in countries all over the world, and today the cluster acts as the strongest life science cluster in the North. It competes with life science clusters in UK, Switzerland and the United States (e.g. Boston)[7].

6.3. EXTENT OF SECTOR MOBILITY

Incoming mobility – from UCPH to the industry

Overall, DP employs 51 professors, associate professors, and lecturers. Six of these have been employed in the life science cluster. Head of Department Flemming Madsen (previously employed at Coloplast), Prof. Sven Frøkjær (Associate Dean until the 1st of September 2016 and previously employed at Novo Nordisk), Prof. and Deputy Head Bente Gammelgaard (previously employed at LEO Pharma), Prof. Annette Müllertz (previously employed at Novo Nordisk), Prof. Claus Selch Larsen (previously employed at Lundbeck), and Prof. Thomas Rades (previously employed at Roche, see main report).

Together these six employees represent 15 percent of the permanent staff of researchers. Except for Anette Müllertz, all the above mentioned have had an academic career of some length prior to their employment in the life science cluster. However, except for Flemming Madsen (2010), none have been hired directly from the industry within the last six years. Thus, the number of newly recruited sector mobile researchers is decreasing.

[7] Kilde: Lægemiddelindustriforeningens årsrapporter 2014 og 2015

Outgoing mobility - from UCPH to the industry

During the last three to four years, DP has let go of 14 associate professors. Seven associate professors went to the industry – and all for Novo Nordisk. In proportion to above-mentioned number of associated professors and professors (39), this is a relatively high number (18 percent).

Our interviews at DP indicate that mobility come in "waves". Novo Nordisk has a significant number of persons employed with a PhD, but only limited number of employees, who have work as associate professors or professors at UCPH or other universities. The number is assumed to be at a maximum of 10-15 persons.

6.4. EFFECTS OF SECTOR MOBILITY

We have interviewed two sector mobile researchers at DP and two researchers from the industry, who have previously been employed as researchers at DP. Additionally, we interviewed two management representatives (Head of Department and former Associate Dean at the Faculty of Medical Health and Medical Sciences), who both have been employed in the industry and at UCPH.

Furthermore, we interviewed a representative of the board of directors at Novo Nordisk and a representative of the HR-department at UCPH. To supplement these interviews, we also question ask the management representatives on how sector mobile researchers function in the industry and university environments.

Hence, a large part of the interviews is conducted with individuals, who have been sector mobile themselves. However, the important thing is that the assessments coincide and they are also supported by interviews with managers, who have not been researchers themselves.

Organisation and cooperation: most of the interviewees also have a role as research leaders at DP. The generally attitude among them is that research results (e.g. patents), and not necessarily articles, is the goal of the research.

Network with the industry: virtually without exception, sector mobile researchers have a larger network with the industry than other researchers. This network is important for research collaboration projects, case studies in teaching and the realisation of results with commercial potential.

Research focus: sector mobile researchers have more experience with the development of the industry. Thus, they have a better understanding of what "the next relevant question" is within the industrial environment, which research should try to address.

Research methods: sector mobile researchers are more qualified to deselect outdated research methods compared to their non-mobile colleagues.

External funding and business collaboration: sector mobile researchers are often significantly better at convincing businesses and foundations to support co-funding research projects.

Education – Bachelor, Master's, and PhD´s.: sector mobile researchers often use more case examples based on the industry in their teaching, and they facilitate contact between businesses and students – especially students at the master and doctoral level. Hereby, teaching becomes practice-oriented and inspire students to consider careers in both the private and the public sector – or a combination. Hence, sector mobile researchers are also role models for the next generation of researchers.

Continuing education: in this area, DP is very active and the department offers three types of programmes: summer schools, MIND (Master of Industrial Drug Design) and MPRA (Master of Pharmaceutical Regulatory Affairs). All three programmes are applied by employees of the life science cluster and more than 100 complete one of the programmes annually. The sector mobile researchers are active in the programmes.

It may be added, that some interviewees also point out that sector mobile researchers might experience that previous colleges are further in their work within several areas. Among others, these areas are knowledge of public rules, funds, and financing options.

6.5. EFFECTS OF SECTOR MOBILITY ON THE CLUSTER

As a part of the analysis, we also interviewed a person from the management group of the life science cluster with significant relations to the institute (*Katrine Luise DiBona*, Novo Nordisk), as well as two researchers: *Harrie Boonen* (employed at Lundbeck and with previously experience at Novo Nordisk and Zealand Pharma) and *Lars Hovgaard* (employed at Novo Nordisk). We sought to find the driving forces in their own careers and the impact of their job experiences as university researchers when they work in a firm.

All interviewees generally stress the good relation between UCPH, and DP in specific, and the life science cluster. This includes joint research projects, industrial PhDs, and dissemination of knowledge in general.

Harrie Boonen has been employed at both Novo Nordisk and Zealand Pharma, as well as Lundbeck. He emphasises that all businesses have their own organisational culture, development, and research. Often, former employees know all employees at the department and have a good sense of upcoming research results. Therefore, sector mobile researchers have an important role as contact points for firms that wish to get in contact with DP or that consider collaborative projects.

From 1995 to 2000 *Lars Hovgaard* (LH) worked as associate professor at the department and as Head of Department from 2001 to 2007. Also, he worked in a start-up firm for 1 ½ years (Galencia in Malmö). Finally, from 2007 he has worked at Novo Nordisk. Parallel with his job at Novo Nordisk, he is chairman of censors at DP and adjunct professor.

LH emphasises some of the same points as Harrie Boonen. Research in firms is more narrowly focused on business-critical problem-solving in light of a shorter time frame.

However, firms also need more long-term research carried out at the university. In this regard, sector mobile researchers serve as an important link between the two types of research. For LH,

a crucial difference in culture is, that sector mobile researchers do not lose themselves in details but continue to focus on the objective of the research.

6.6. DRIVING FORCES BEHIND THE SECTOR MOBILITY

Table 6 shows our assessment of identified driviers to sector mbility and their individual strength. The strength of the each factor is evaluated at a scale from 1-5 (1 being a weak effect on sector mobility, and 5 implies a strong effect).

Table 6: Drivng forces behind sector mobility at Department of Pharmacy, UCPH

	Assessment (1-5)	Comment
National and regional frameworks and strategies		
Government programmes to increase sector mobility	1	The Ministry of Higher Education and Science does not have programmes to enhance sector mobility.
Special career tracks	3	The universities have a number of opportunities. However, these opportunities are utilised differently between individual universities and institutes. The act on university job structures can be considered somewhat rigid
University strategies		
General university strategy and focus on sector mobility	2	UCPH does not have a strategy with the objective to enhance sector mobility, though the university does not resist the development of sector mobility that exist locally.
Tradition and culture of sector mobility in selected departments	4	Generally, DP has a positive position towards sector mobility. However, among others, the economy limits the enhancement.
Flexible leave opportunities	2	The department can assign researchers with leave of absence in cases where researchers wish to apply for jobs elsewhere. Or research sabbaticals can be granted, but are limited due to lack of resources.
Flexible positions	2	The department has one professor employed, who work part-time at the institute and the remaining time at a firm.
Research profile and match with industry needs	5	Research of the department matches the needs of the industry.
Other knowledge bridges		
Spinouts	2	UCPH produces a number of spinouts, however the framework conditions do not support an enhancement in the number of spinouts. Therefore, UCPH lacks behind, which means the university is lower ranked, than e.g. the Technical University of Denmark, within this field.
Amount of joint research projects	4	The extent of collaborative projects is high.
Business culture		

R&D-intensive cluster/sector	5	The life science cluster has a number of high-quality research activities, which may be relevant for university researchers.
Business involvement in university research	3	The life science cluster is strongly committed to university research.
Publication culture	3	Varies greatly between businesses, though some firms are relatively open-minded and allow a high publication level.
Physical proximity	4	Most of the persons interviewed stress that proximity is an important factor.
Successful sector mobility	4	

The national framework conditions enable the universities to implement a number of initiatives to promote sector mobility, cf. the case of Aalborg University. The rules allow e.g. flexible leave of absence possibilities and shared positions (part-time associate professorships and professorships), etc. However, these possibilities are rarely used at UCPH (cf. 3rd row in table 6).

However, at DP a strong culture and tradition for sector mobility exist. Together, our cases indicate that industrial work experience of the Head of Department plays a role. One example is Flemming Madsen (FM), who has worked as researcher at Coloplast from 2000 until 2009 following a 10-year tenure at the University.

FM considers it essential that there is at least a handful of the department staff, who have industry knowledge and experience to provide a broader perspective to the department's key deliveries like research, teaching, and dissemination. But it also plays a role in the leadership of the department.

In some cases, the department has allowed researchers, who wish to apply for a job elsewhere, to take leave of absence. However, the department does not offer this opportunity anymore, as mobility has primarily been outgoing the last couple of years (cf. above). As other university entities, the Department is faced with cost savings, which will be implemented in the coming years. According to the interviewees, the savings may result in a shortage of facilities, staff, an increasing difference in wages between institute and industry, etc. This furthers outgoing mobility of researchers to industry.

At the present, associate professorships are limited. Only one professor, Anette Müllertz, has a part-time associate professorship at the institute, while she is employed at *Bioneer* the remaining time. Bioneer is a partly public supported knowledge and consultancy firm (GTS institute) within the field of biotechnology and pharmaceutical science, it is located Hørsholm outside Copenhagen, and it has a turnover of approximately 50 m. DKK annually. At other UCPH departments and universities spinouts and framework conditions for innovation play more important roles for mobility than they do at DP – this even though the institute has a few examples itself (cf. the above example of Lars Hovgaard).

The extent of collaborative projects is important for mobility. A significant number of collaborative projects contribute to the establishment of numeral contacts across sectors, whereby people get familiar crosswise segments.

The fact that the life science cluster has powerful and developing position have a significant impact on mobility. Wages in most firms within the cluster a relatively high, the firms are R&D intensive, and several of the interview persons indicate these factors have influenced their career path, hence they have applied for jobs in the industry. A position in a business of the life science cluster meant that they, easily and without bureaucracy, got the necessary research facilities, which was not possible at the university.

However, the publication culture within businesses may be a problem. If researchers want to return to a job at the university, normally it is a requirement that researchers have a certain "list" of publications – also during job positions within firms. However, the magnitude of publications firms allows their employees to publish differ. As a main rule, publications are something researchers working in firms partially must make outside normal working hours.

Finally, the proximity factor influences mobility. Many Danes do not want to apply for a job that implies that they must move, commute during weekends, or that one's partner has to change job. Therefore, mobility is supported, as the life science cluster is in the metropolitan area of Copenhagen. It is anticipated that constructions of new incubator environments, e.g. COBIS, further strengthen the proximity factors, as start-ups will be located side by side with researchers.

Prof. Rades is highlighted as one of the role models in the main report.