

Research as a Service: The Role of Competence Centers in Bridging Industry and Academia

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Abstract: Turning research results into commercial success has been one of the key economic challenges since the beginning of the industrial revolution. In this context, most recently an increasing impact of Public Private Partnership (PPP) approaches can be observed. In this chapter, we focus on a specific form of PPP which aims at establishing so-called “Competence Centers”, i.e. research institutions explicitly joining the forces of academic and industrial research. Based on two examples in the Austrian funding program COMET, we describe the basic setup of such centers, and discuss the specific roles and challenges for various types of research staff, including their roles and career paths. Finally, we sketch the most important lessons learned, before we conclude with a brief summary and outlook.

Introduction

Since their earliest days, research in the sense of a systematic search for novel insights has served as one of the fundamental pillars of academic institutions, especially universities. Yet, starting with the industrial revolution, more and more research labs outside universities have emerged and today cover the majority of research activities worldwide. On the other hand, at least in technology-oriented domains, the roles of academic and industrial research have traditionally been separated in a rather clear way: while universities have been considered to be the primary place for exploring fundamental scientific problems of long-term relevance, industrial research labs are typically dealing with evolving technologies from an application-oriented point of view and a short- to mid-term time to market.

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As a direct consequence, the process of transferring results of academic research into the profit-oriented world of commercial exploitation has become a task which is crucial and non-trivial at the same time. On a more fundamental level, this also relates to the ongoing debate on basic research versus application-oriented research if it comes to creating innovation. In fact, commercially relevant innovations are not necessarily due to advances in basic research. Instead, very often they result from new combinations of existing technologies or from the adoption of certain technologies to new operating fields or markets. Such combination links individual novel technologies back to particular technologies that existed before and at the same time suggests a route to be tackled due to novelties arising in technology [1]. Moreover, this re-use and combination also underlines the importance of interdisciplinary approaches for innovation processes and is one of the key factors for open innovation initiatives. As a side effect, especially the identification of the combination of existing technologies, as well as the application of existing technologies to new areas and markets may pose certain problems on traditional organizational structures and call for new ideas and solutions.

Hence, typical recent approaches to solve this problem include launching an increasing number of “Universities of Applied Sciences” usually co-financed by industry partners, encouraging university staff and/or students towards the creation of start-up companies for the commercialization of their ideas, establishing comprehensive national and international funding programs like, for instance, “Horizon 2020” in Europe, with a clear focus on cooperative research projects, and fostering various other forms of Public-Private Partnership (PPP) activities. While some of these attempts have indeed started to successfully bridge the intrinsic gap in between these two worlds, in many cases still they have not yet succeeded in sustainably opening the widely deplored “academic ivory tower”.

Nevertheless, from the perspective of the research staff employed, this new type of research institutions seems to provide a distinct third way of pursuing a research career just in between academia and industry, following a “Research as a Service” paradigm which understands fundamental and application-oriented research performed at a competence center as a certain service to its industry partners. Hence, in order to pinpoint their relevance for the intentions of the present book, in this chapter we will address a particularly interesting example, i.e. so-called “competence centers”, which may be considered as a special form of PPP, with the intrinsic potential to join and integrate the best of both worlds. On the other hand, also the related challenges are non-trivial and require a deep mutual understanding of the individual stakeholder interests as well as the ways to reconcile them.

In this context, we focus especially on the role and perspective of the individual researchers working at such a competence center who, in various stages of their career, have to come to terms with a rather diverse ecosystem and at the same time are aiming at steady advances in their individual personal and professional development. Our (sometimes rather personal) observations, conclusions and recommendations are based on more than a decade of active involvement in two differ-

ent IT-related Austrian competence centers, and cover different stages of the centers' evolution as well as different levels of related activities, roles and responsibilities, ranging from the point of view of early-phase PhD students over the intermediate stages of senior researchers and project managers up to the perspectives of a CEO and a university professor, respectively.

The remainder of this chapter is structured as follows: using the example of the Austrian COMET [1] program throughout, we start with describing the basic framework, funding scheme and key marginal conditions, and sketch different implementation approaches. Next, we discuss the resulting implications for the various stakeholders, and focus on the position of the individual researcher who is confronted with potentially rather diverse and maybe even conflicting external and internal requirements and demands, especially as s/he advances along the career path. On the other hand, it turns out that this specific situation is also able to offer promising opportunities and prospects which are often easier to be realized than in traditional settings. In this context, we discuss especially the need for efficiently integrating strategic and application-oriented research as well as the key role of interdisciplinarity for guaranteeing a sustainable success of both the center and the individual researcher. Finally, we conclude with presenting and analyzing a set of concrete opportunities and pitfalls based on our experiences, and discuss general consequences for a researcher's career and the decisions to be taken along.

Basic Framework

Following several successful Scandinavian examples, in 1998 the Austrian Government decided to introduce a competitive competence center program under the name *Kplus* as well as two smaller program lines called *K_{ind}* and *K_{net}*, which has led to the creation of around 40 new research institutions with roughly 1,500 scientists from academia and industry working on a broad spectrum of jointly defined research topics. Since 2006, the successor program COMET (Competence Centers for Excellent Technologies) has continued this success story, while introducing some significant changes compared to the original conception, most importantly the distinction of three different sizes of competence centers: *K2 centers* typically comprise around 150 researchers and focus on top-level research of clear international visibility, *K1 centers* with usually around 50-70 scientists and a slightly lower funding rate, and so-called *K projects* which are already rather close to the market and thus are supposed to be even smaller in terms of size and public funding. In this way, the declared goal of strengthening the culture of cooperation between industry and science and building up joint research competences and their commercial exploitation has been addressed on several levels [2].

Generally speaking, thematic openness has been one of the characteristics of the mentioned programme lines, and has led to establishing K2 competence centers on mechatronics, biotechnology, future mobility, material engineering and tribology, while K1 centers cover a much broader range of topics ranging from cli-

mate change and bioenergy over electrochemical surface technology, metallurgy, polymer engineering and wood engineering as well as medical robotics and pharmaceutical engineering to telecommunications, software engineering, big data and IT security, to mention but a few.

In this chapter, we will focus on two especially noteworthy examples in the area of Information and Communication Technologies (IT), i.e. the Telecommunications Research Center Vienna (FTW) which has been operational from 1999 to 2015 [3], and the Center for Virtual Reality and Visualization Research (VRVis) established in 2000 [4]. Following slightly different models, both centers have managed to establish a critical mass of top-level research in their respective domains and thus to achieve significant international visibility, moreover they provide instructive insight into the typical life cycle of such an institution.

Due to the fundamental requirement of focusing on pre-competitive collaborative research, typical research projects within a COMET center comprise at least two industrial partners together with the center and often additional academic partners. Hence, for both centers it was crucial to form consortia of significant industry members, including large national and international companies as well as SMEs. Here, the two centers were following slightly different approaches: FTW has been founded at a point time where the telecommunication industry had to manage the transition from a telephony network operator to a broadband multimedia service operator. This disruptive trend required not only the development of new technologies and network products but as well the establishment of skills for technology management and technology roll-out and network provider services. Thus, FTW focused on evolving broadband technologies such as optical network technologies, broadband access technologies, mobile communication technologies, fixed-mobile convergence and next generation network services. This applied research focus was mainly driven by the incumbent network operator in Austria, in high synergy with the interest of several equipment manufacturers. This fact strongly underlines that disruptive technologies need comprehensive research activities in many areas, resulting in cooperative R&D approach even among competing manufacturers in short- and mid-term technology implementations.

On the contrary, VRVis has been following a more diversified approach, focusing around “Visual Computing” as a cross-cutting research topic which allows structuring its projects in a way such that the interests of orthogonal industry partners could efficiently be served. As a consequence, VRVis projects are usually built around one specific research topic with at least two industry partners (typically a large partner together with one or two smaller ones, or alternatively a larger set of smaller partners), often with additional partners complementing the consortium. In total, this has led to the impressive number of currently (Feb 2016) 30 industry members of VRVis, while FTW never exceeded the number of 15 active industry partners at one point in time. Moreover, in the case of VRVis, it is notable that apparent networking effects lead to a rather vivid and continuous evolution of the partner consortium, whereas in the case of FTW, the composition of industry partners has been relatively stable over time, and major changes in the

consortium have mainly happened in the context of an imminent re-application for further COMET funding.

Another basic requirement of the funding program concerns the integration of academic partners, whose overall contribution to the budget of a COMET center has to reach 5% at minimum. Again, both centers have been following rather different approaches in this respect: while FTW has been going for the integration of a large number of universities and research institutions, VRVis has been built mainly around a strong collaboration with two specific institutes at Vienna University of Technology and Graz University of Technology, and only recently has started to approach further academic institutions, including two research groups from University of Vienna. This has led to a relatively close integration of the academic researchers with the center's staff, while in the case of FTW, research groups from the universities usually have participated only in very specific research projects, and the active interworking between academic partners and the centre has remained on a much more occasional level.

Note here that one of the most important advantages of running a project within a competence center is related to the relatively easy access to funding. While for other funding schemes, like EU projects, there is a huge and still increasing competition within each project call, in the case of competence centers it is up to them (and their research partners) to decide about the distribution of available funding. In our case, the funding scheme for both centers was of course identical: following a competitive call issued by the Austrian Research Agency FFG, the centers were asked during the application phase to specify the desired percentage of public funding which could reach up to 45% overall, for a total duration of seven years. Together with the 5% budget contribution from academic partners, this has resulted in a required industry contribution of 50%. Hence, simplifying *ad extremum*, basically every Euro coming from industry has been complemented by another Euro originating from public money. Note that the attractiveness of this funding scheme is further increased by the fact that the cost for any research project are usually shared between several industry partners, leading eventually to a much higher funding leverage, where the individual contribution of one industry partner manages to leverage a total research effort of a factor of typically up to 10:1.

As far as the overall internal structure of COMET centers is concerned, in general they have relative freedom in defining their internal setup in a way which is most effective for their specific circumstances (for instance, for a long time FTW went on without a dedicated scientific director and left the corresponding strategic decisions rather on the level of area managers, while the position of the scientific director at VRVis originally has been a rather strong one, only recently transferring a larger part of strategic responsibility to the area managers as well). However, as a mandatory requirement from the funding body, each center is thematically structured into 3–5 main research areas, where the collaborative projects themselves are eventually situated. To this end, after several refinements, FTW has been following roughly the well-known layer structure typical for today's communication systems (cf. the notorious seven layer model according to ISO/IEC 7498),

implementing research areas on Information Processing, Networking, Networked Services and Economic and User Aspects of Telecommunications. In contrast, also in this respect VRVis has rather been following a structure oriented along orthogonal topics, distinguishing the four areas of Rendering, Visualization, Visual Analysis and Computer Vision.

Within these areas, several basic types of research projects have to be distinguished, including: (a) strategic research, working on topics of longer-term interest and attracting a slightly higher funding rate due to the higher risk of such activities, (b) application-oriented projects, addressing pre-competitive research interests of the companies with a potential of mid-term commercialization, (c) participation in national and international research projects, for instance EU projects, which attract additional external funding but usually require some complementary funding from within the center, and (d) so-called *Non-Kplus* projects, usually commercial activities on a bilateral basis without any significant public funding and addressing rather directly the needs of the industrial research partner. For instance high-tech consulting, proof of concept projects, technology demonstrations, or advanced prototype developments are typical such research services, where the industrial partner in addition may have specific interests to protect related IPRs.

As a consequence, one of the main challenges of running such a center concerns the maintenance of an adequate balance of these different types of research. Concerning the interplay between strategic and application-oriented research, again both centers have chosen different implementations: at FTW, strategic research has been performed mainly in dedicated strategic projects (one per research area), whereas at VRVis, a per-project approach has been followed, such that each project typically includes a certain portion of strategic research, together with the larger part on application-oriented research. Eventually, these aspects also have major impact for the resulting governance structure. However, coming up with an optimal solution here is considered a non-trivial issue by itself and out of scope for the present chapter.

Researchers and their Roles

Having outlined the fundamental structure of COMET competence centers in the previous section, we will now turn towards another key topic of this chapter and discuss the role models as well as opportunities, challenges and obstacles for researchers employed at a competence center at various stages during their career.

First of all, we would like to stress that, generally speaking, competence centers provide an environment which, for several reasons, tends to be much more complex than scientists would encounter when joining a traditional research institution focusing either on basic research or on high-tech engineering only, respectively. As a result, an extraordinary degree of flexibility, broadness, versatility and self-discipline is expected from a successful team member. This is to a major extent due to the already mentioned distinction between strategic and application-

oriented research. From a researcher's perspective, usually activities will be performed in both directions, with a mixture depending on the individual scientific interests of the researcher as well as the business needs of the industry partners and the center itself. As a consequence, it turns out that successful staff members are sought after for application-oriented activities much more than they would like to be, and thus sometimes have to fight for getting sufficient space in the strategic research to be able to follow their own long-term interests. On the other hand, being allowed to work on disruptive technologies which are not immediately ready for deployment at industry partners is considered an essential prerequisite for the researcher himself as well as the center as a whole, and last not least provides also the most important justification for public funding.

Secondly, as competence centers are deliberately positioned at the touch point between academic research, industry research and industrial product development, so are in most cases also their staff members. Hence, ideally, researchers working there should be interested in fundamental scientific questions as well as the application of their results in a practical context. However, in reality it turns out that joining both these worlds is not an easy task and results in major challenges both for the institution and its staff members (an aspect largely neglected by the funding bodies). From the researcher's perspective, this dichotomy leads immediately to a rather strong triangle of forces between the different expectations and requirements posed from university partners, industry partners and the center itself. Concerning the expected output, universities mainly aim at high level publications at international conferences or scientific journals of high impact. Typically, this is not interesting at all to industry partners, quite on the contrary: they usually expect working prototypes, testbeds or even almost market-ready products (which, however, according to the funding rules are not considered part of the research output). Finally, the center as such is primarily interested in a well-balanced mixture of both types of outcomes which allows conforming to the key figures stated in the funding contract, including corresponding IPRs. As an immediate consequence, researchers are competing on two very different fronts: they have to come up with publications of sufficient quality to be accepted by renowned international conferences while at the same time spending significant implementation efforts that are supposed to match business level quality as offered by the industry partners which, on their part, usually do not have much of an interest in publications.

On the other hand, of course, working much closer to industry than in a traditional academic context offers also extraordinary opportunities. One important aspect concerns the process of defining research topics of actual interest also from a market perspective. While, by definition, this may sometimes reduce the individual research scope within collaborative projects, it also reduces the risk associated with following overly hazardous approaches. Eventually, if everything is following a balanced approach, there is usually still space for new ideas to be followed in the framework of complementing PhD theses. Moreover, also for prospective PhD students, it might be advantageous to develop a profile which is somewhat related to industry needs, at least as soon as it comes to applying for a decent job there.

Another, in a certain sense even more relevant, aspect of such a close interaction with industry partners concerns the possibility of (at least sometimes) getting access to comprehensive real-world data which, after appropriate anonymization and/or rescaling, may often serve as invaluable input to scientific investigation and are suitable to raise the interest of the international research community by itself. Of course, granting such access to data is by no means a matter of course even for well-connected industry partners, but requires the long-term development of a very sound trust relationship. On the other hand, a scientific approach for e.g. a sound analysis of “Big Data” often by far exceeds the available resources, especially of smaller industry partners, and hence is able to grant them considerable added value if sourced out to a collaborating research center – “Research as a Service” in its purest form. In a similar way, only by extensive cooperation with industry partners it is possible to implement large scale proofs of concept, e.g. in the form of “living labs”, enabling research activities within real-world environments. On the other hand, such approaches often result in a very high international visibility and are thus very attractive for researchers as well as industrial experts.

However, in a long-term perspective, too close a focus on industry interests may also become dangerous, especially concerning the requirement of international visibility, which today is indispensable for the development of a decent scientific career. Hence, as a consequence, it turns out that it is essential for the success of the center and all its members to strictly maintain and support an international perspective of the research projects, for instance through joining related networking platforms which allow achieving significant visibility outside the local environment. Interestingly, this is one of the lessons learned by the funding agency FFG in the course of the transition from the *Kplus* to the COMET program, which by now finally supports also the integration of partners from abroad in order to further diversify the consortium. Moreover, especially in Europe, there is a variety of suitable platforms for attaching to the international research community, starting from COST actions [5] which are rather easily accessible and provide well-established mechanisms to connect to interesting international partners, to the active participation in European Framework projects like, e.g., Horizon 2020 [6]. Indeed, even coordinating EU projects may fall into the scope of a competence center, as demonstrated for instance in the case of TARGET [7], a European FP6 Network of Excellence with a total of almost 50 international partners.

Having discussed the diverging forces and resulting tensions faced by researchers in competence centers from a rather general point of view, we will now switch perspective and put a closer eye to the individual staff member, his/her basic role and corresponding evolution. In this context, we first have to clearly distinguish between two very different career models, which for simplicity reasons we will call “researcher” (or “scientist”) vs “engineer”. While this distinction is common also within universities or industrial research labs, it nevertheless has some particularities in the case of competence centers. Hence, very broadly speaking, a career as engineer typically implies that by far the largest part of the work is devoted to activities directly linked to industry interests. In the context of ICT, this boils

down to tasks like implementing code, managing all kinds of systems and maintaining them, setting up and running experimental testbeds, performing measurements, etc. In addition to these very technical skills, also experience with project management, requirement engineering, programme management, dissemination and even exploitation activities might be requested from high-level engineers within an applied research center. Even more, the ability to establish and maintain a close cooperation with industry partner based on trust and flexibility represents one of the most important requirements to be fulfilled for the success of long-term research partnerships.

In contrast, scientists essentially maintain a longer term, structural perspective on the evolution of technology, in the ideal case joining advancements in theory with their application in a practical context. Hence, their work is usually of a more experimental nature, developing and testing novel ideas, approaches and solutions e.g. by means of simulations. Moreover, they may serve as a valuable resource in terms of observing and evaluating also advanced research trends, thus making them accessible to interested industry partners, for instance through offering dedicated tutorials or other suitable forms of technology transfer.

As already mentioned, at this point it is important to note a very particular observation: the relation between researchers and engineers at competence centers is often somewhat reverse to what we know from traditional research institutions. In contrast to the latter ones, at competence centers it is implicitly assumed that researchers gain significant benefit from their relatively larger “freedom”, while it is the engineers who are supposed to rather serve the interests of the industry and therefore, at least in a certain sense, are considered to be of even higher value to the center. Hence, engineers are no longer supposed to just providing support to the researchers, but instead put straight into focus of commercial success. This, most importantly, is also reflected in the salary scheme which needs to be structured such that the career path as engineer remains sufficiently attractive, especially in relationship to competing job opportunities directly with industry partners. Note that, in this context it is less important to focus on the total income figure but on indicators which are really measuring the performance of an engineer, who have to be judged on their performance in a way completely different to typical researchers. Altogether, keeping these two worlds in balance can easily turn out to be one of the trickiest challenges in application-oriented research centers.

Concerning the longitudinal career development steps (in the sense of “*level-n*” staff members) we will focus in the following on the researcher case and distinguish between the following five typical career stages:

- *Research assistant*: For students, this stage offers usually the first point of contact with proper research, for instance in the context of a Bachelor, Master or Diploma thesis. They are typically engaged on a part-time basis for various support tasks and, depending on their abilities, have already in a very early stage the opportunity to participate in smaller or larger projects, thus also coming into contact with potential future employers after their graduation.

- *Junior researcher*: A second typical entry point into a competence center is placed at the transition from Master to PhD students. Junior researchers are already hired according to a rather specific profile, depending on the tasks they are supposed to fulfill in their research projects. Step by step they are directed towards doing independent research (first in the context of single work packages, later on also assuming larger responsibilities on a project level), which is eventually supposed to lead to a PhD thesis. Hence, as an indispensable prerequisite, they are also assumed to be aligned to a research group at an academic partner (because competence centers as such are not allowed to confer academic grades). This fact has turned out to be the source of major concern, as (again by definition) prospective PhD candidates don't follow the research interests of a university professor as closely as PhD candidates working directly at the university. Hence, in the worst case, junior researchers have virtually to hunt for willing supervisors – a problem that only can be solved if university staff is closely integrated into the center's operation and thus draws sufficient benefit from this activity.
- *Senior researcher*: Similarly to graduation representing a very natural transition point between research assistant and junior researcher, the transition between junior and senior research most prominently is marked by having finished a PhD thesis. Most academic systems have recognized the importance of this particular career stage where researchers are typically extremely prolific as well as mobile because of their interest in making new experiences, and systematically offer dedicated “post-doc” positions for one or two years. However, this is not the case in Austria, where post doc contracts at universities usually have to be signed for a duration of four to six years, with the clear goal of finishing the so-called “habilitation”, i.e. another academic degree establishing the ability to independent teaching on a specific scientific field (*venia legendi*). Competence centers can be much more flexible in this respect and thus become very interesting for post-docs from abroad. Very naturally, the tasks fulfilled by a senior researcher comprise the independent acquisition and management of full research projects in very close contact with the industry partners. Apart from (sometimes major) budget responsibility, this requires also a convincing set of social skills which have to be developed over time (of course with the support of the center as major beneficiary). At the same time, senior researchers are expected to guide their team members also scientifically, and thus to produce a significant amount of high-level publications which is vital for the scientific reputation of the center. Finally, very often also some teaching involvement at university partners can be observed at that stage.
- *Key researcher*: In contrast to what has been discussed so far, the position of a “key researcher” may be interpreted in different ways. The basic idea, of course, is to have a small number of internationally visible excellent scientists involved into the center's activities as closely as possible. There are basically two ways to achieve that: either by attracting university professors

and recruiting them as part-time staff members beyond their usual university duties, or by supporting the potential of internal staff members on a senior level such that, eventually, their scientific impact outside the center becomes comparable to an associate or even full professor. Key researchers typically are responsible for one of the main research areas of the center (or at least a large part of it), which includes strategy development as well as accountability for staff hiring, development, guidance and performance appraisal. Naturally, the budget responsibility now comprises the entire area and implies large scale acquisition activities. At the same time, it is expected to contribute significantly to the scientific evolution of the center, for instance as supervisor of PhD candidates (which again implies closer links to one or more research groups at a partner university). In the course of time, the activities of a key researcher tend to develop strongly towards managerial tasks which, due to resource limitations, might threaten the individual scientific development.

- *Scientific director*: The scientific director of a center is often part of the innermost management circle (e.g. together with a CEO and a CFO) and bears the full scientific responsibility for the center. As this position typically would require a rather distinguished scientific profile corresponding to a full professor position at university, together with excellent management and communication skills, we consider it a very special case and basically outside of the scope of this chapter.

In a similar way, the career path as an engineer typically includes similar stages, i.e. *assistant engineer* (often students completing internships at the center), *junior engineer* (graduated students at the beginning of their professional career), *senior engineer* (experienced staff members with broadly developed competences, often already leading their own teams) and *key engineer* (with rather comprehensive responsibilities). However, while the career steps of researchers and engineers on first glance seem to exhibit a rather parallel structure, there remain nevertheless deep differences between both paths, and it is one of the most important tasks for the center management to be constantly aware of both worlds and to strictly avoid a clash between the cultures of engineers and scientists.

Coming back to the five basic stages of a scientific career in the context of a competence center as presented above, a very natural question may arise: to which extent is it beneficial for the staff member as well as for the center to follow more than one of these stages within the same institution? By now, it is well accepted that international mobility forms an essential part of a researcher's life, hence it is rather straightforward to assume that there should be some limitations here. Considering this issue step by step, the transition from research assistant to junior researcher is a rather natural one and should not pose major problems, on the contrary: hiring a potential PhD candidate before graduation offers a good way to evaluate his/her potential and avoid wrong hiring decisions. Similarly, the transition between senior researcher and key researcher bears lots of potential for the successful evolution of the center, as it offers the strong incentive for exceptional sen-

ior researchers to influence the overall strategy and develop their own field into a research area of its own, thus providing a strong contribution to the vitality and development of the center. Moreover, researchers at this stage often have already significant personal or family constraints, such that it is important for them to get a long-term development perspective without the need of changing the institution.

In contrast, the transition between junior researcher and senior researcher is an issue of much larger ambiguity. On the one hand, finishing a PhD thesis should go basically hand in hand with the fundamental life-time decision of heading for an academic or an industry career. For potential future academics, it is important to demonstrate their mobility at this point in time, whereas vice versa for the center it might be highly beneficial to be able to attract post-docs from outside and absorb their ideas and knowhow (which typically is at a certain peak immediately after finishing a PhD thesis). If, however, the long-term perspective of a staff member is rather on the industry side, there is no need for him/her to stay still in a research environment instead of starting a distinct industry career as soon as possible. And indeed, it is quite interesting to observe that roughly half of the PhD students at a competence center assume an industry job at this point in their career, while the other half tends to stay in research. Finally, also from the perspective of an industry partner, this is the perfect moment to hire a researcher who, in previous years, has attained in-depth knowledge in the areas relevant for the industry partners (up to a significant amount of “learning on the job”), which, at the same time, have had enough opportunities to check whether a particular junior researcher fits into an enterprise and is able to fulfill his/her expected duties.

Some Lessons Learned

From the discussion in the previous section, it should already have become clear that positioning a competence center exactly in between academic and industrial research offers a couple of unique opportunities, as well as very specific challenges and obstacles. Looking at the opportunities first, almost all of the center’s researchers massively profit from the contacts they automatically get through their work. Again, these contacts are subdivided between industry partners as potential future employers, and international research organizations as potential places for developing or furthering a research career. At the same time, the opportunity to gradually develop personal responsibility for topics, activities, later work packages or even projects within a relatively secured environment offers unique learning opportunities which can be of priceless value for a future career both in industry and academia. As already mentioned, this is also true in the reverse direction, i.e. from the perspective of industry partners as potential future employers.

As far as research itself is concerned, the setting of a competence center by definition grants that research ideas and directions are developed in close affinity to potential (and usually promising) fields of application. In this context, the overall economic development of the market has of course a very significant influence, as

has become extremely evident in the case of FTW: FTW has been established in a period of rapidly growing communication markets which subsequently reached saturation, leading to a severe cutting of research budgets as well as to shortening significantly the “time to market” perspective. Thus, in the course of time, long-term strategic research has become very difficult to agree with the industry partners, which in a next step significantly reduced the attractiveness of the center both for new staff and for new partners. Eventually, the maturity of the (fixed and mobile) telecommunication market has also decreased the general interest in the field and, as a consequence, may have contributed to the decision of closing down FTW at the end of 2015.

In fact, this example is also quite illustrative in terms of the life cycle of competence centers: at the very beginning of the *Kplus* programme, there have been strong expectations from the funding body that for a competence center it should be possible to develop an independent standing within the runtime of originally seven years such that, in the best case, a center could continue afterwards without further baseline funding. Subsequent experience with this programme has shown that this position was a relatively daring one, which in the meantime has led to the more or less standard procedure that COMET centers reaching the end of their respective funding period usually participate in a new COMET call. Of course, this has to go hand in hand with a more or less fundamental re-orientation of the research scope, however it seems that having an already established structure in terms of industry consortium and best practices is not a disadvantage in this process. On the other hand, for the COMET programme to be attractive, it is mandatory to avoid any automatism in this respect, and consequently in every call so far a certain number of existing centers have failed to convince the reviewers and subsequently have disappeared from the landscape, as part of their natural life cycle.

For the individual researcher, a competence center offers various clearly defined entrance points as well as adequate responsibilities, while requiring an unusual degree of flexibility. This provides of course again additional experiences which can become extremely useful in a potential future career in industry as well as academia. However, it turns out that it is also important to identify a good exit point in order to make maximal use of the center for one’s personal career. Finally, due to the limited lifetime of competence centers, they are more or less always in some sort of transient state and require flexibility also in this respect.

In general, it should be underlined that in our experience the collaboration within the industry consortia, typically composed of partners with widely different sizes, resources, and expectations which, to make matters worse, sometimes may even be direct competitors, is working remarkably well. This fact should by no means be considered as a matter of course and, on the contrary, deserves high attention as a fundamental prerequisite for the successful operation of such a joint competence center. One of the key challenges in this context concerns the agreement of a mutual acceptable regulation of the Intellectual Property Rights (IPRs). In fact, this can easily become a major stumbling block due to the broad variety of

possible models as well as the potentially conflicting interests of the involved stakeholders. A pragmatic solution could, for instance, first of all distinguish between results from strategic vs. application-oriented research, and furthermore differentiate IPRs according to the degree of involvement of a stakeholder in the corresponding project(s). Under such a scheme, IPRs from strategic research could remain rather closely to the center and be used and exploited by all partners either in research projects or in joint application-oriented project arising from a strategic activity. On the other hand, IPRs from application-oriented projects could be primarily linked to the project partners and be made available to further stakeholders either after a certain time or under special commercial conditions. Of course, this sketch represents just one possible solution out of many others, and in any case would require careful adaptation to the specific situation of a particular center.

While originally the establishment of competence centers also had targeted at creating additional momentum for startup companies close by, the concept has turned out to be less successful in this particular aspect. On the one hand, it has not been unusual for startups to use the funding options within a COMET center for performing their first R&D projects, on the other hand it has been a relatively rare case that the creation of a startup has been attempted from within a center. Hence, it seems that young entrepreneurs require different forms of support, and the idea of using competence centers as incubator institutions should be viewed at without overly exaggerated expectations.

Summary and Conclusions

Almost two decades after its establishment, the Austrian competence center program *Kplus/COMET* may safely be considered a huge success and has significantly contributed to bridging the gap between science and business, which has been its central goal from the very beginning [8]. This is especially true for the two examples we have more closely illustrated in this chapter. While both FTW and VRVis have been firmly rooted in the area of Information Technologies, their individual approaches have turned out to exhibit significant differences, which in turn have led to interesting consequences. Most importantly, we have seen that the concentration on a single market, like telecommunications in the case of FTW, bears major risks: on the one hand side, this “horizontal” approach has led to a quite consistent consortium which has allowed to easily realize the original idea of joint pre-competitive research projects with the participation of two or more industry partners, but on the other hand the strict dependency on the economic success in the telco market has become a severe drawback in times of increasing competition and decreasing research budgets. More specifically, this has led both to a steady decrease of available funding from industry partners as well as a continuous shortening of the time horizon for research activities. Together with a couple of further adverse circumstances, this has eventually led to closing FTW down after 17 years of successful operation. Compared to this, the “vertical” strat-

egy followed by VRVis, based on strong scientific knowhow in methodologies which are applied to a broad spectrum of use cases from potentially very different markets, has proved to be more sustainable, leading to a steady growth in terms of number of partners as well as size of budget.

Despite of their key importance for the success of the competence center as a whole, such strategic decisions are of rather limited impact if it comes to the role and responsibilities of the individual researcher who is employed at such a center. Here, once more we would like to strongly underline that, in our experience, competence centers provide an extremely interesting third way for developing a research career on different levels. For students and young researchers, they offer an interesting and versatile entry point into the world of application-oriented research which maintains sufficient independency from industrial day-to-day business such that a solid perspective for own research work culminating in a Master or PhD thesis, respectively, is provided. At the same time, depending on the personal interest, it is easily possible to grow into different levels of responsibility within the portfolio of various research projects, thus developing also important managerial skills in an environment which is still relatively protected. Altogether, this contributes to developing a personal profile of increasing interest for the job market.

Similarly, for the more experienced researchers on a post-doc or even higher level, the portfolio of development opportunities is remarkable as well, as long as the scientists maintain a strong personal intention to align individual research interests to the requirements of potential industry partners, and thus to contribute also to the commercial success of the entire center. Amongst others, this emphasizes also the strong need of interdisciplinary research, which on the other hand can be easily realized due to the limited size of the organization (e.g. typically 50 researchers in the case of a K1 center) and the common research baseline. Hence, using the options originating from the interplay between strategic and application-oriented research, the options for senior researchers are rather broad, ranging up to the development of a new research area of its own and thus seamlessly evolving into the role of a key researcher heading an own team of considerable size. Still, also in this stage, employment opportunities at industrial partners are as valid as ever, while developing an academic career requires additional effort in order to keep touch also to university life. This can be reached for instance via external teaching, which is usually highly welcome with the university as it combines high technical quality together with application-oriented relevance, or through sharing positions between the center and an academic partner, e.g. on a part-time basis. Later on in the academic career, this leads to developing a profile with several unique selling points, for instance if it comes to demonstrating sufficient experience with acquiring and managing third party funds, which can easily turn into key assets during the application process for tenured or non-tenured professor positions.

As, by construction, competence centers *a priori* have a limited lifetime (as already mentioned, in Austria they used to be granted for seven year periods, more recently this has been extended to eight years), this may at first glance seem to reduce the attractiveness for highly skilled employees. However, this is mainly true

for the more senior positions and can easily be counteracted by opening this type of positions strictly on an international level. On the other hand, the very same fact leads to a strong incentive for both junior and senior researchers to further develop an existing competence center into new research fields which, together with new industry partners, at the end provide a convincing setup for submitting a new COMET application, in order to allow the developed knowhow to become both sustainable and fruitful in novel directions. Again, this only increases the relevance of the researcher profiles, which can also be demonstrated by the fact that, quoting FTW as our example for one last instance, within the relatively short period of half a year after the final decision to close down the center, more or less all researchers formerly employed there managed to find adequate positions outside which have allowed them to continue their work under new auspices.

Summarizing our findings and experiences, competence centers have established a sustainable new form of research institution which are very attractive both from an industry and a personal researcher's perspective. For industry partners, participating in a center offers tremendous possibilities of getting access to cutting edge research trends as well as outsourcing research topics which are of mid-term interest but cannot be dealt with due to lack of resources. For researchers at a competence center, the resulting "Research as a Service" paradigm offers the opportunity of performing their work in an application-oriented context, and thus provides an excellent occasion for developing a research profile which, after all, is equally relevant for high-level academic and industry careers. In this sense, competence centers contribute significantly to bridging the gap between academia and industry which eventually provides a clear win-win situation for basically all involved stakeholders.

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