Developing a Framework to Manage a Pharmaceutical Innovation Ecosystem: Collaboration Archetypes, Open Innovation Tools, and Strategies

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Abstract

Based on an in-depth case study of the ecosystem of one of the world´s largest healthcare companies including internal and external data collected since 2009, and through over 50 interviews with key stakeholders from Biotech companies, Academia, Contract Research Organizations, and Venture Capital firms this article elaborates on the challenges and opportunities of collaborative innovation in the pharmaceutical industry. As firms prepare for more open approaches towards new product development we recognize that the variety and frequency of possible models for co-development has increased and poses respective challenges to the management of all partners and tools involved in this "ecosystem". In the first step of developing our framework, we carve out core management and organizational aspects of collaboration including risk management, success measurement, options of professional partnership management, and level of organizational involvement. In a second step we identify the variety of partnership models and open innovation tools in biopharmaceuticals, creating four different archetypes of open innovation: Insight-, Workbench-, Access-, and Development-tools. In step three we conclude with strategy relevant patterns in open innovation by allocating the tool-archetypes along the important management aspects in a consolidated matrix. The potential strategy implications and options can be considered by managers planning and implementing open innovation, and by scholars conducting further open innovation ecosystem research.

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1 Introduction: Towards open innovation in biopharmaceuticals

In recent years, the innovation challenge in the healthcare sector has become very prominent (e.g. Paul et al., 2009). R&D expenditures increased constantly (e.g. PhRMA, 2012) while internal R&D productivity decreased, putting substantial pressure on pharma's R&D pipelines (Mullard, 2012). Drug approvals for new molecular entities and biologic license applications declined or stagnated (Hughes, 2009), and a majority of pre-clinical and many promising clinical assets was found outside of big corporate healthcare companies (Mayhew, 2010). The internal resource limitations of pharmaceutical R&D managers and the promising knowledge available outside of their own organizations induced increasing external search for innovations. Managers were forced to consider more cost effective and resource efficient innovation models such as externally sourcing or cooperatively developing innovations in partnerships. The paradigm of open innovation (Chesbrough, 2003) captured the pharmaceutical sector (see Koch, 2010; Munos, 2006; Perakslis, Van Dam & Szalma, 2010; Smits & Boon, 2008) and rather linear- changed towards more integrative or circular innovation models (see in general Rosenberg, 1982) so that multiple collaboration, partnering, and open innovation methods in the industry have advanced over the recent years. Already with the emergence of biotechnology clusters across the globe, the linkages between firms and institutions were explored under the notion of R&D collaboration. Co-work between pharmaceutical and biotech firms, local startups, and industry and universities became prevalent and alliances were formed (e.g. Pisano, 2000; Carpenter et al., 2004; Laroia & Krishnan, 2005). The teaming up between actors enables the sharing of costs, risks, competencies, and supports innovation (Powell et al., 2002). Besides alliances, licensing deals to access key technologies increased, consortia were set up to tackle general issues of the industry, equity-based R&D joint ventures became prevalent, and standardized R&D processes are often outsourced to contract research organizations (for an overview see Hu et al., 2007; Hagedoorn, 2002). The growing

pressure to find breakthrough innovations and the opportunities to develop core processes and technologies in cooperation with partners, today results in more complex open innovation processes and in further rethinking conventional R&D models (Munos, 2009; Paul et al., 2009; Everts, 2006) including the externalization and re-design of drug discovery (Mayhew, 2010) and development-stages through to clinical trials (Orloff et al., 2008). Managers planning and implementing new organizational models based on collaborative approaches need to align interests and goals and overcome communication barriers and cultural hurdles with their partners. They must find the right open innovation strategy within a network of professional partners, the open crowd, and a variety of emerging open innovation tools – and they need to manage it. In this paper we develop a strategy framework of open innovation relevant for managers in the pharmaceutical industry and beyond, intending to improve the understanding of the current external innovation landscape to steer more complex open innovation ecosystems. We therefore propose the following research question: What are the characteristics of partners and open innovation tools in a collaboration ecosystem and how do these characteristics influence open innovation management and strategy? We use a broad 'open innovation' definition of *purposive inflows and outflows of knowledge to accelerate internal innovation* (Chesbrough, Vanhaverbeke & West, 2006: vii) as this perspective can include various partners and external knowledge sourcing concepts. The article is organized as follows: We first provide an overview on recent developments and challenges before we explain our research method. We then present our findings which we discuss with regard to creating open innovation strategy, managerial implications, and theoretical contribution in the last parts of the paper.

2 Recent developments and collaboration challenges

Impactful changes to the nature of co-developing innovations in biopharmaceuticals emerged in recent years, as we will outline in the next section. **Cooperative *technology* development** rather

than only technology transfer is increasing (Lessl & Douglas, 2010). This can support overcoming a potential discontinuity in the technological cycle (see Anderson & Tushmann, 1990) but has added growing complexity to the landscape of collaboration in the pharmaceutical sector. Compared to out- and insourcing activities or joint R&D partnerships, such technology-based collaboration provides much more insights between two or even multiple parties, thereby abandoning certain competitive advantages so that the nature of partnering becomes more difficult. **New potential partners** join the innovation system: Consumer and user communities (in general Potts, 2008; Hemetsberger & Pieters, 2001) develop or modify products by themselves (Bullinger et al., 2012; Kuenne et al., 2011), users can be integrated into selective stages of development processes (Smits & Boon, 2008), and the crowd contributes to developing new solutions (Lessl & Asadullah, 2011; Norman et al., 2011). **New collaboration models** are tested, for example involving a multitude of partners within syndicate innovation venturing (Vertes, 2012): R&D functions or parts thereof are separated from corporates and then combined with a venturing concept in an independent incubator, located geographically close to leading academic centers and serving as legal entity. R&D project- or startup proposals can be submitted, are funded and further enhanced through this independent incubator (Vertes, 2012: 75). The concept enables unexpected collaborations between partners who would not have met outside the syndicate venturing model. The **culture for innovating** apparently plays an increasingly important role (Zhong & Moseley, 2007). Startups and smaller biotech companies, and especially biotech clusters, are assumed to be equipped with enormous innovative potential through entrepreneurial culture (e.g. Ruel, Frolova & Groen, 2012). This may be part of the explanation why biotech companies do collectively produce more new medical entities than big pharmaceutical companies (Munos, 2009). Large corporates hence attempt to imitate the biotech configuration by creating smaller centers of excellence as independent entities (Pisano, Weber & Szydlowski, 2014), thereby leveraging the positive effects of more internal entrepreneurship and innovation-driven

culture (Behnke & Hueltenschmidt, 2011; Douglas et al., 2010; Hunter & Stephens, 2010). Moreover partnership-based innovation models have entered into a much more **long-term and strategic mode** (see Torrey & Grace, 2012) including the co-development of innovation strategies. The notion of innovating collaboratively has changed from one-way relationships, such as outsourcing, towards multi-dimensional relationships; and extended towards the core competitive edge of many large pharmaceutical companies, technologies and processes (see also Lessl & Douglas, 2010), associated with a very long-term and strategic focus. Eventually, **more funding** is required particularly for academia and academic spin-offs (Klein, Haan & Goldberg, 2009), often resulting in co-development activities within the networks and ecosystems of venture funds (see also Vertes, 2012).

How are organizations impacted by these developments? Although many firms and institutions in biopharmaceuticals have by now made significant experience with open innovation approaches, there are still substantial failures and imbalances in partnering and alliances (Lawler, 2003). Some articles have dealt with issues impacting partnerships and the partnering organizations. Certain (power) asymmetries and financial issues between parties have been emphasized, particularly in industry-funded university research and often with bad deals on both sides (Lawler, 2003). Other authors conclude that better alignment of common interests and goals is required in models of more proactive alliance management (Laroia & Krishnan, 2005). Cultural differences between partners (see Lessl & Douglas, 2010) could be improved through mechanisms of trust generation, such as by specifying interests and values more precisely in advance in order to resolve possible issues prior to their occurrence (Carpenter et al., 2004). Communication issues, represented for instance by "*words meaning different things*" (Lessl & Douglas, 2010), need to be resolved and decision making needs to be optimized (Hughes, 2009). Moreover, better management of intellectual property (IP) and the specific skills to translate research into commercial products (Vertes, 2012) or integrate new technologies and processes into development is crucial to the innovativeness (Cohen & Levinthal,

1990). Whereas outsourcing R&D activities were often mainly managed by the core R&D and procurement function, much attention is now paid to making more strategic contracts and to selecting the right strategic partner for collaborative innovation development. This requires novel multi-partner and cross-departmental (R&D, Business Strategy, Marketing, Procurement, Legal) approaches and dedicated management; and also a change in organizational DNA towards open innovation culture (see Behnke & Hueltenschmidt, 2011). More professional management of partnerships (see Lessl & Douglas, 2010) is necessary as types of knowledge and the search and integration mechanisms for knowledge (Almirall & Casadeus-Masanell, 2010; Laursen & Salter, 2006) change in a more complex innovation landscape, potentially increasing the costs of absorption and making open innovation management multifaceted (see Enkel, Gassmann & Chesbrough, 2009; Carlile, 2004; Grant, 1996; Cohen & Levinthal, 1990). Organizational capabilities and organizational structures hence seem to matter when facilitating open innovation (e.g. Bianchi et al., 2011; Dahlander and Gann, 2010) and the impact of open innovation on organizational capabilities and design is becoming a particular research topic in management literature (e.g. Keinz, Hienerth & Lettl, 2013; Ihl, Piller & Wagner, 2012; Lakhani & Tushmann, 2012). There is indeed a sufficient rationale for creating dedicated partnering functions (e.g. Eager, 2010) handling the complex management- and organizational challenges of collaboration and open innovation.

The focus of this study

The reviewed articles have shown that pharmaceutical organizations and their potential partners are impacted by the requirements coming along with co-working in increasingly complex innovation ecosystems. The emphasized core aspects of organizational and managerial challenges and even failures in partnering reflect that a more comprehensive and structured perspective on important management and organizational elements is necessary. This perspective could rather be embedded within innovation ecosystem approaches (e.g. Kim & West, 2014) because firms usually have to

organize a number of partners and collaboration options. Whereas research on organizational patterns of open innovation is emerging (e.g. Keinz, Hienerth & Lettl, 2013; Ihl, Piller & Wagner, 2012; Lakhani & Tushmann, 2012), studies integrating a partner-perspective into a structured overview on key management elements *and* different open innovation tools have apparently not been established so far. Based on the review of literature and pre-interviews with pharmaceutical managers we designed our research around core aspects of biopharmaceutical partnering: We cover the major partners of the biopharmaceutical innovation landscape. We consider a detailed list of available collaboration options and open innovation tools. And we investigate the most important patterns of partnership- and open innovation management. This allows us to draw a more comprehensive framework comprising different collaboration archetypes, various open innovation tools, and the core organizational and management aspects to prepare organizations for an open innovation ecosystem.

3 Method: Case-study and interviews

We apply an in-depth case study of the ecosystem of one of the largest global healthcare companies, using internal and external data collected within the company since 2009. The company operates in the field of pharmaceutical and medical products and generated revenues of almost EUR 20 billion in 2013. The pharmaceutical division, in focus of this study, engages about 40.000 employees and is committed to research and development of novel drugs while constantly improving established products and therapies. The R&D expenses equal over 10% of revenues and about 25% of employees are engaged in R&D, in facilities in Europe and the United States. The company cooperates with different types of partners in research and development. The main collaborators are biotech companies, academic institutes and contract research organizations. Beyond this core set of

partners, venture firms as well as the crowd and individual researchers play an increasingly important role for the pharmaceutical sector.

Use of internal databases and orientation interviews with global managers

The case company investigates and stores information about open innovation approaches from internal and external sources. Internally, managers conduct innovation workshops and meetings in which key internal stakeholders from different departments and business unites share their knowledge and insights. The company has set up a dedicated unit to manage external innovation. As a basis for this project we were able to make use of frequent contacts to this function and internal data stored in workshop documentation, interview protocols and decision reports. We furthermore cover a global perspective by including information from managers from departments in different countries such as Germany, the US, China and Singapore. A detailed list of managers that frequently took part in such meetings and workshops is available from the authors.

Collecting information from different types of partners via interviews

For our study we were able to conduct interviews with 52 organizations, among them many prestigious firms and institutions in pharmaceutical R&D. The interview partners were chosen in collaboration with our case-study company based on the criterion that they represent key collaboration partners or potential preferred partners of the firm. Planning data collection, we deliberately put the focus on three key actors of the industry that are presumed to play different roles in appropriation of knowledge and expertise (Cohen & Levinthal, 1990): 1) Academia or university labs likely produce less targeted knowledge and are often partnered with at earlier stages; 2) biotech firms provide more targeted knowledge or possess a respective “target” and are closer-to-market partners; 3) additionally we interviewed few contract research organizations, which can be considered as the providers of the most explicit knowledge due to their very task-specific

involvement. The focus is on the key co-development partners of our case-study company, academic institutes and biotech firms. This was decided in pre-interviews with managers. A comprehensive list of participating firms and institutions is available from the authors. The following table provides an overview about partners included:

Table 1: Overview on interview sample, distribution, and therapeutic areas

	Academia	Biotech	CRO
Europe	14	14	2
USA	6	8	0
Asia	6	1	1

Therapeutic area / expertise	Count
Oncology	17
Cardiology	9
Women's Health	2
other indication	1
Technology (Chemistry)	9
Technology (Biomarker)	5
Technology (Antibodies)	3
other Technology	6
Total	**52**

We furthermore use information from interviews with 10 venture capital (VC) companies that cooperate with pharmaceutical companies. In these cases, data was collected over interviews in up to two hour meetings. The information from internal managers and these first two groups of interviews represent the basis of information about different types of partnerships, risks and expectations, and how to manage and measure collaboration. Information about the interviews from the partners and

VC companies was transcribed and stored in table format in a comprehensive database, which is also used internally at our case-study company.

Operationalization of data collection and evaluation

We cover core aspects of partnering that are the existing state of the art for internationally operating pharmaceutical firms. We designed a questionnaire that included the reasons and drivers to collaboration, the organizational framework and structures (capabilities, culture, and process), preferred open innovation models, as well as risks and success measurement parameters of different partners combined in closed and open ended questions. The data was collected via phone interviews and in-situ that had an average duration of 45 minutes. Table 2 provides an overview on the selected core patterns of collaboration and open innovation management. These elements are considered to represent consecutive important steps of open innovation management. They have been revealed during literature review and pre-interviews with managers. First, we focus on learning about drivers (intentions and goals) for collaboration, assumed to improve the ability to choose the right open innovation tools and to ensure better alignment of interests and goals (e.g. Laroia & Krishnan, 2005). Second, we investigate the risks associated with external partnering considering this knowledge as improving decision making processes (Hughes, 2009), IP management (Vertes, 2012), and trust generation within a company and between parties (Carpenter et al., 2004). As a third core aspect we look at how partners measure effectiveness and success of open innovation approaches. Metrics can be an important medium to improve communication (Lessl & Douglas, 2010) by adhering to aligned interests and goals and to foster more professional management and a better culture for open innovation (Behnke & Hueltenschmidt, 2011) when success becomes visible. Eventually, we studied how the partnerships are managed, particularly with regard to dedicated management-tools and functions and with regard to the level of organizational involvement. We assume this factor to be inevitable to cope with the increasing complexity of the innovation landscape which requires better

decision tools for external knowledge integration (Almirall & Casadeus-Masanell, 2010), e.g. through professional partnering units (e.g. Eager, 2010) and more involvement and interplay across functions (as already stated by Cohen & Levinthal, 1990).

Table 2: Overview and operationalization of key elements of collaboration management

	Collaboration Drivers	**Collaboration Risks**	**Success Measurement**	**Professional Management**	**Organization Involvement**
Selection criteria, underlying assumption (example references)	*Choice of partner and tool:* In advance alignment of interest and goals between collaboration partners (Laroia & Krishnan, 2005) Specification of interests between partners (Carpenter et al., 2004)	*Anticipate collaboration challenges:* Improve decision making (Hughes, 2009) Improve IP mgmt. (Vertes, 2012) Generate trust within company and between partners (Carpenter et al., 2004)	*Enable collaboration management:* Improve communication (Lessl & Douglas, 2010) Enable success visibility to improve innovation culture (Behnke & Hueltenschmidt, 2011)	*Assign responsibilities:* Manage increasing collaboration complexity (Almirall & Casadeus-Masanell, 2010) Use of dedicated partnering- (Eager, 2010) or interface functions (Cohen & Levinthal, 1990)	*Consider org. involvement:* Cross-functional involvement to exploit and assimilate external knowledge (Cohen & Levinthal, 1990) Organization design aspects (Keinz, Hienerth & Lettl, 2013)
Operationalization in the study	Pre-specification of key drivers with managers Rating of drivers by interviewees Open question on *collaboration intentions*; coding of all interviews for "drivers, goals, intentions"	Open interview questions on *perception and avoidance of risks* Coding of all interviews for "risks, issues, hurdles, failures"	Open interview questions *how to define and measure success* Coding of all interviews for "success, measurement, metrics"	Interview question about *support for set up and management of collaboration* Coding of all interviews for referenced features of professional collaboration support	Presented collaboration models to case-study managers and rated depth of organization involvement Created involvement levels
Additional	All interviews have been coded and structured in knowledge blocks in a consolidated Excel database enabling creation of statistics, figures, overviews, and comparisons between different partners and collaboration features Additional collaboration features have been asked during the interviews in order to generate a more complete picture and test for consistencies, e.g. experience with collaboration; important criteria in partner selection and during collaboration; preferred collaboration models; key strengths and weaknesses of collaboration partners; importance of funding and funding models				

Collecting further information on open innovation tools employed

During the interviews with partners and VC companies we also stored information about different open innovation tools already applied in the field. We operationalized the investigation of the open innovation and collaboration tool landscape as follows: We collected a list of available and applied models with managers of our case company; We asked all interview partners for collaboration tools

and preferred collaboration tools; We coded all interviews with regards to references for specific tools and which goals they serve; We created four archetypes of tools and presented that information to managers within the external innovation function, to the business development, early licensing group and to managers of the different therapeutic research areas. This led to an overall list of tools assigned to archetypes that we further use in this paper in order to depict the portfolio of tools relating to different partnering strategies.

All results presented in the findings and the discussion sections have been iterated and validated by presentation to managers from the case-study company after interim and final analysis.

4 Findings: Managing Open Innovation

We present a three-step process aiming to provide guidance for managers and researchers developing and managing open innovation strategies. The first step reveals the results of our study with regard to the selected five key elements of collaboration. The second step describes the landscape of open innovation and collaboration tools and creates different archetypes based on the major objectives the tools serve. The third step in the discussion section reveals strategy impact and options.

Step ONE: Understanding Partners and Collaboration

In the following section we present results from global interviews for the key elements of collaboration.

The drivers and intentions for collaboration

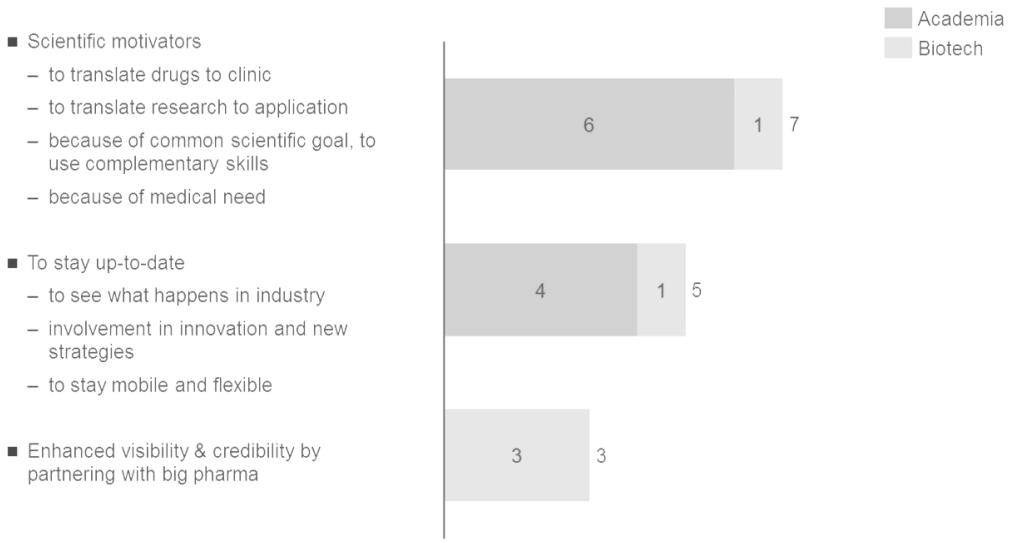
> *"Mission is to, within a reasonable period of time, translate drugs to the clinic (bench to bed-side"* and *"involvement in innovation and new strategies."* (Biotech Academia CRO Interview #4; #18)

A first aspect to be considered when managing open innovation is the collaborator´s intention for teaming-up with another company: In line with the trend of increasing earlier stage partnerships (e.g.

Moore & Walker, 2009), the scientific motivation for collaboration is becoming an enormously important driver and particularly the most important intention for academic organizations. It includes "access to drug discovery and development expertise" and "exchange of scientific expertise". In contrast, "access to markets and brands", e.g. the reputation and value of a companies´ brand or the companies´ developed markets is more important for biotech companies, often partnering for commercialization purpose, whereas Academia focuses on early stage research. The access to funding or financial support is ranked as the most important item when considering the answers of all respondents. Managers and executives perceive teaming up with partners as an essential part of their financing strategy. About half of all interview partners have had contact with venture capitalists. While various managers perceive funding as critical in "*early stage phases*" (e.g. #7, #13, #17), some mention that sustainable funding *across all stages* is the crucial point: "*Taking an idea, target or compound and getting it through to phase II, especially in the transition to clinical: NIH grants are only for preclinical studies, as soon as you have the FDA to do clinical trials, the grant is gone.*" (#31) Besides the financial input of VC partners, many interviewed managers consider the development expertise offered to startups and early-stage companies as "very important" or "most important". In our interviews and additionally collected data in the VC landscape we noticed a changing pattern from financial contribution to a knowledge- and technology-access approach in new collaboration ecosystems. New concepts which are much more "*collaborations of mutual interest*" (#6) between partners such as VCs, corporates and startups are emerging and obviously different from traditional, rather financially motivated approaches or focused build-to-buy concepts. VCs propose ´beyond financial investment` collaboration opportunities between firms within their ecosystem.

Additional intentions to collaborate mentioned by managers during the interviews were grouped into scientific motivation, staying up-to-date, and visibility & credibility (see figure 1).

Figure 1: Additional drivers to collaborate



The scientific drivers are strong across academia: Six respondents referred to translation of findings to the next stage, to complementing of skills, and the medical needs. In comparison, only one biotech manager mentioned translation as an additional need. Staying up-to-date and keeping market-trends on the radar is of particular relevance for academic institutes. In contrast to biotechs, academic institutes have a stronger need to gain insights into industry-developments, learn about market innovations and strategies. Biotechs are naturally closer to these developments and often well embedded in the later-stage innovation landscape, e.g. present on the most important innovation conferences. However, they specifically mention the requirement to enhance visibility and credibility through relationships with large pharmaceutical companies.

In conclusion the drivers for open innovation suggest that more collaborative knowledge creation rather than just knowledge-, competency- or risk-sharing (e.g. Powell et al., 2002) will take place between firms and institutions. Managers need to plan their approach based on whether a scientific, a strategic and commercial intention, or a financing strategy is the basis to enter open innovation, which may further define risk- and collaboration management approaches.

Risks of collaborations

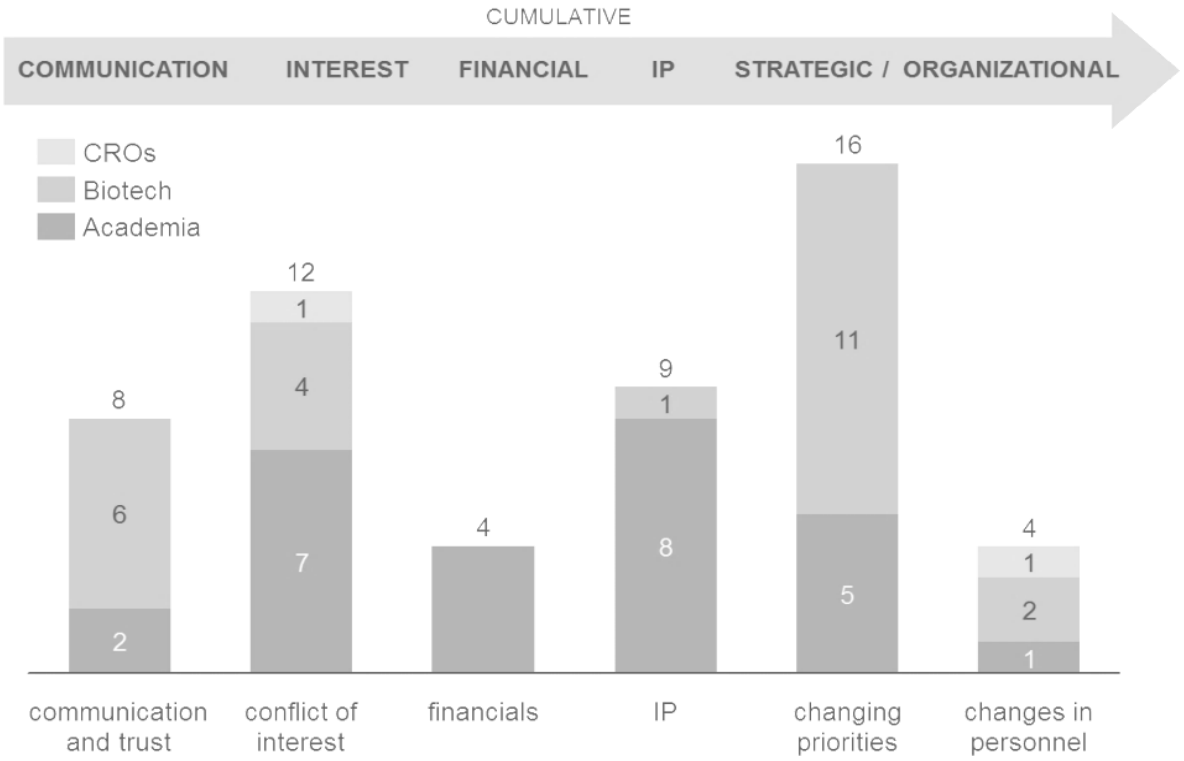
> *"Energy, resources and time are committed to a project. If the project fails (unsuccessful, difficulties, broken agreements), this is a lost opportunity.* […] *A small biotech and a big pharma have very different views on the world.*" (#5; #25)

While collaboration can be good to share risks (Powell et al., 2002), it becomes likewise important to anticipate and handle different types of risks and perceived risks by collaboration partners. Relationship risks can even turn allies into rivals (Gomes-Casseres, 2000). Open innovation tools and inter-firm collaboration obviously include various risks for the involved parties, for instance when stronger parties exploit their strengths over one or a multitude of smaller partners (Lawler, 2003).

Interview partners relate risks mainly to the co-work within the collaboration rather than to financials or IP. In the following we explain the findings starting with the most frequently mentioned types of risks. Particularly for biotech managers suddenly changing priorities are an issue. When working in pre-commercialization phases of drug development long-term timelines play a major role and are hence key to success. The longevity and sustainability of a started cooperation is therefore important. Because larger corporate partners are often more focused on development efforts or commercialization and are also incentivized by commercial success, strategic changes can happen frequently. Interview partners described this as a risk of *"stopping the development because of change in strategy*" (#31). The problem is apparently also present when collaboration is not stopped but when it is clearly deprioritized. Moreover, conflicts of interests are on top of managers risk lists, for instance the wish for purely financial returns versus knowledge development interests, or prioritizing patents (corporate) versus prioritizing publications (academia). Respondents even feared that they are prohibited from publishing (e.g. #51). Conflicts of interest can be multifaceted though and are often closely related to communication, perceived for instance as "*not being clear at the outset of the partnership about goals and objectives of both groups*" (#25) and "*misjudged*

expectations" (#22). In fact communication and trust issues within collaborations are an important risk specifically mentioned by biotech managers. Interviewees refer to "*miscommunication*" (#33) or even different cultures (#30). Thus, the specification of interests in alliances and collaborations (see Carpenter et al., 2010) and their clear communication (Lessl & Douglas, 2010) can help to overcome these hurdles even when different cultures clash in partnerships.

Figure 2: Clustered risks perceived in collaborative innovation (cumulative levels)



The IP risk is more significant for the academic sector, likely due to the fact that they are commonly in phases of generating IP, of which the management is more difficult as compared to the state when IP *is* already established. Partners fear to "*give up control over assets*" (#31) or they end up in a state of: "*You must not tell anything, even not to your lab members.*" (#51) Financials are only mentioned by academia: A few of our interview partners stated that funding is not sufficient or that no long-term security is provided (e.g. #18, #37). Apparently, academia occasionally has to deal with insolvency of corporate sponsors. Changes in personnel are identified as a risk by all parties, biotech,

academia, and CRO for instance when "*key people suddenly leave [because] the partnership is very dependent on people-to-people relationship"* (#29); but this seems to occur less frequent. Based on our findings we were able to create different cumulative risk levels which are displayed in figure 2 (above).

Most of the raised potential failure risks, from problems of aligning interests (Laroia & Krishnan, 2005) to communication (Lessl & Douglas, 2010) and trust issues (Carpenter et al., 2004), are found in our study and beyond that strategic and organizational risks seem to matter. A more structured view on these risks may help managers to improve collaboration outcomes. They need to plan their open innovation approach considering whether rather operational risk levels such as timelines or stability of teams play a role or if rather strategic risks such as financial or IP related threats have to be considered.

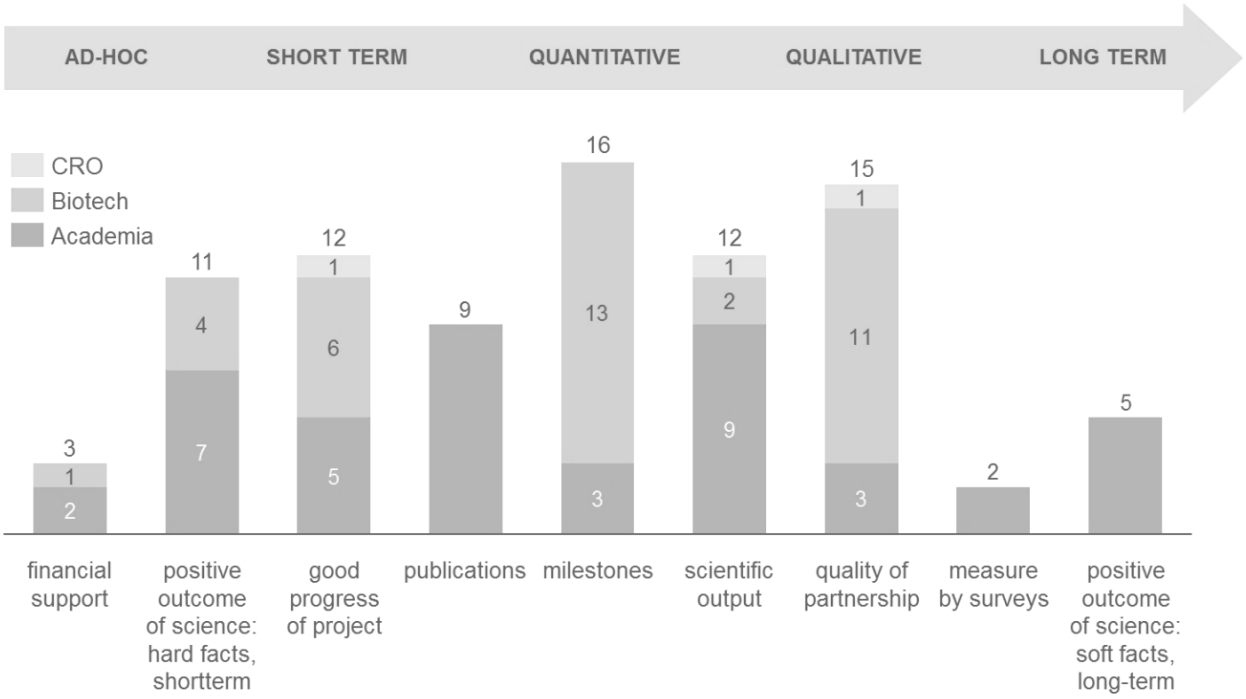
Measuring success of collaborations: Metrics

> *"Too much emphasis on financial aspects in early stages: when it's all about milestones and the bigger goal (to be in phase III in 3 years, to help patients) is lost… think more ahead! In x years, we make billions, so we don't have to think about 1/2 million now."* (#32)

Measuring effectiveness and success of open innovation and collaboration needs to match the intention and goals of the partnership. To manage alliances successfully it is important to track critical success factors, ranging from measuring the core process to parameters such as entrepreneurism, commitment, team work, management skills, or number of products (or alternative outcomes) derived (Rautiainen, 2001). We want to explore how partners actually measure collaboration effectiveness and put this into a structured perspective (see figure 3). We found that a major parameter to operationalize the measurement of success in R&D partnerships is to make use of simple metrics, such as meeting working plans, milestones, timelines and contractual terms and conditions (#2, #8, #39, #50). This is particularly valid for biotech companies, of which 13 managers

mentioned to measure success in this way while academia mostly relies on other measures: Scientific output, publications, good progress of projects and the short- and long-term positive outcomes of science. Moreover we found measures for the quality of the partnership, for instance the project and partnership durability (#38) and whether "*relationship has grown [and] more trust*" (#22) was established. Some partners apply parameters such as "*number of new projects*" (#26) or even focus on soft-measures such as "*long-term commitment*" (#50). In other words, collaborative work seems to be evaluated positively if there is a "*win-win*" (#19) situation for all involved parties. Hardly any organization in the sample stated to apply survey methods. However, some success measures introduced are rather related to strategic or multiple-partner collaborations than to traditional contract- or project-based R&D. At least five of the interviewed academic partners apply long-term positive outcome measures including "*common gain of knowledge*" (#19) "*intellectual contribution*" (#9) the workforce & equipment built-up as well as the broader technology use on both sides (e.g. #4, #7, #9, #13).

Figure 3: Clustered success measurements in biopharmaceutical collaborations



Concluding, the metrics to assess the success and progress of individual open innovation projects or entire partnerships can be structured along a range of rather quantitative towards more qualitative approaches which we created based on our findings (see figure 3). Particularly for some of the traditional partnering methods our interview partners explained that outcomes are rather measured on a quantitative basis, e.g. milestones and scientific output or publications. Within project-based partnerships or multi-project partnerships outcomes are measured mainly by the progress of the individual projects. Applying rather long-term measures and general quality of partnerships seems to become more important when it comes to managing strategic partnerships or innovation ecosystems.

Professional open innovation management

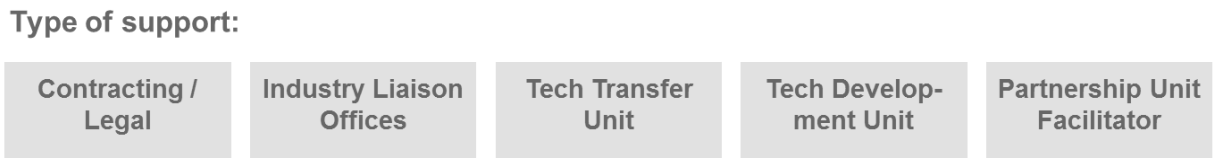
> *"Establish two different systems to handle the partnering company – differentiate between inside and outside."* (#9)

Managers planning various forms of collaborations and the degree of organizational involvement and change need to know whether the partner organization has the respective competencies and capabilities in place to cope with the approaches. The important organizational capabilities to translate research results into development or successful products (Cohen & Levinthal, 1990) should be available on all partner sides or the collaboration model itself may require a respective professional organization. We find that almost all managers and researchers in our study are increasingly interested in mutual partnerships ´on eye-level` rather than conducting contract research. Interview partners stated true partnerships as their preference: "*Collaboration of mutual interest*" (#6), joint development of new concepts (e.g. #30) or an "*alliance of equal with good interaction and give and take: Both sides learn things they didn't know before*." (#23) In contrast, only a very limited number of partners has a preference for contract research and mentioned their priority for "*collaboration for cash with little interaction between the partners.*" (#23) With

increasing use of R&D collaboration and especially mutual and strategic development co-work (see Torrey & Grace, 2012), the management of partnerships is professionalized (see also Eager, 2010).

Almost half of all respondents in our research state to have deliberate support for the set-up and management of collaboration in place in their organization. Practically all academic institutes had established certain forms of partnership support. They use industry liaison offices, technology transfer or technology development offices, have set up partnership systems or are supported by partnership facilitators. Based on our findings we created different cumulative levels of professional collaboration support (see figure 4).

Figure 4: Support established for collaboration management in biopharmaceuticals



However, there was still a number of interviewees who were either not aware of professional collaboration support or who were (partly deliberately) not using it sufficiently. Therefore managers should plan their own organizational involvement based on the abilities and goals of the partner.

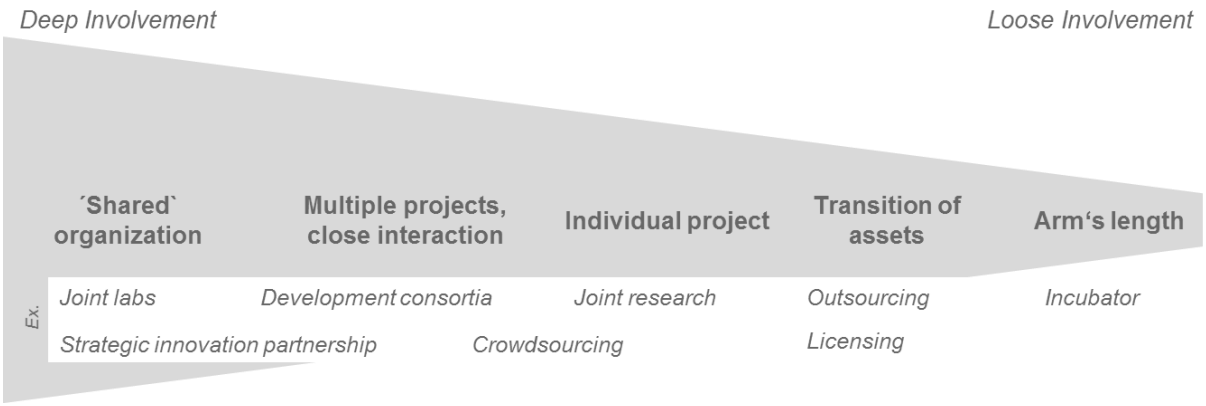
Organizational involvement in partnerships and open innovation approaches

> *"When is an interaction a partnership? When does the management of collaboration change from research unit to alliance management? When do we intensify cooperation?"* (Case-company manager)

Of course, the development of more comprehensive partnering organizations and professional management tools is also strongly related to the depth of organizational involvement in the different partnering concepts and open innovation tools that we present in the next section of the article. Both, deeper and broader organizational involvement may reach far beyond R&D organizations to ensure that absorption and transfer of knowledge into the organization is possible (see Carlile, 2004; Cohen & Levinthal, 1990). In our internal interviews we investigated the different levels of organizational

involvement for some of the major collaboration approaches or open innovation tools. Based on our findings we created different levels of organizational involvement, displayed in figure 5.

Figure 5: Organizational involvement in collaborations (with examples)



Joint laboratories are associated with interaction on organizational level as both parties even meet within the same lab. Strategic partnerships are based on a close-interaction model due to their usual focus on multiple projects and the strategic aspects covered. Consortia, joint research or crowdsourcing are often based on individual projects and involve a small specific part of the organization for a limited time period. Outsourcing or licensing activities is described as a transition of assets with decreasing organizational involvement, and incubator concepts are usually steered “at arm´s length”.

During our research we have found that there is a growing variety of tools that can be used to best suit the requirements described in step ONE. This leads to the next step:

Step TWO: Knowing the Open Innovation Tool-set and Archetypes

When managers plan and design collaboration activities the increasing variety of tools allows for more complete open innovation portfolios and strategies. Today, the options of partnering reach far beyond outsourcing, licensing, or alliances but are rapidly advancing and changing with newly

emerging potential partners (cross-industry, venture capitalists, user groups) and new technological opportunities, such as virtual R&D through bioinformatics (see Rai, 2005) or internet-based crowdsourcing (see Lessl & Asadullah, 2011). During our research we identified a list of partnership models and open innovation tools in biopharmaceuticals which are described in table 3, including examples. Some of them are more traditional while others have emerged more recently. We created four different archetypes based on the intentions and goals for more open forms of innovation. One intention of applying collaboration is to gain *insight* into the innovation landscape, into trends or in order to identify new partners. A second goal of setting up open innovation concepts is to extend the *workbench* in terms of complementing tasks, e.g. letting a partner conduct processes either in order to make the own organization more flexible or simply because the expertise or technologies are not available internally. Third, we recognized the concept of *access*: Getting general access to certain institutions, partners, networks or accessing a new idea pool and respective assets within the early innovation field such as through venture funds or through a licensing deal. As a fourth goal, joint *development* seems to play an increasingly important role and is apparently the most sophisticated format of collaboration. Developing new technologies or new products in joint effort, the co-development of intellectual property, and even collaborative innovation strategies, are found to be major intentions to enter into open innovation. During our research and interviews we assigned the open innovation tools to their major goals (the four main archetypes). Results and examples are listed in table 3.

Table 3: Overview of partnership models and open innovation tools

Model	**Description / *Example***
	Insight Tools
Industry event	A conference, fair or congress to meet potential partners from across the globe in biopharmaceuticals, e.g.to discuss recent trends and activities. *The yearly BIO international convention is one of the well-known events.*

Model	Description / *Example*
Incubator	Lab space rent out to biotech / startups, enhanced by consulting or services (analytics etc.) and funding. Enables insights into biotech and startup landscape, find partners under guaranteed independency from corporate. *Bayer Pharma has established an Incubator at its Mission Bay facilities in California, United States to establish partnerships with early-stage companies. Core facilities of the University of California, San Francisco, and equipment in the work space of Bayer are provided to the incubator companies. (Leuty, 2012)*
Industry consortia (Hu et al., 2007)	Loose industry meetings usually in precompetitive space and focused on general problem solving or regulations, patent & IP issues, sometimes technological issues. Multiple players: Corporates, health organizations and institutions, authorities, biotech, and academia; used for networking, gaining reputation, public funding. *Bristol-Myers-Squibb´s international immune-oncology network as a global collaboration between industry and academia to enhance the scientific understanding of immune-oncology (Marks, 2012).*
Workbench Tools	
Contract research	Direct research (no research grants) with detailed contract and usually unknown outcomes. *Quintiles is a large contract research organization performing various projects from organic synthesis, analytical chemistry, biochemistry, molecular modeling, and medicinal chemistry.*
Outsourcing (Sammons, 2000)	Fee for service agreements, mostly performed by contract research organizations (see above) with a clearly defined service provision such as analytics or screening, in which outcomes are owned by the outsourcing company. *Major pharmaceutical companies follow outsourcing approaches for certain standard R&D processes, often with underlying outsourcing process models to determine the ideal breadth and depth of outsourcing.*
Strategic outsourcing	Fee for service (outsourcing, see above) but covering multiple projects and therefore usually turning rather strategic. Service providers are usually given preferential "right of first refusal". *Contracts with full-service drug discovery service providers like Albany Molecular Research. (Festel, Schicker & Boutellier, 2010).*
Access Tools	
Joint labs (Reed, 2013)	Scientists from pharmaceutical companies work with one or multiple partners in close interaction under defined research goals. The model gains access to academic institutions through close co-work. *GSK´s open lab outside Madrid, Spain with a specific focus to advance the early-stage research in disease prevalent in low income countries (such as tuberculosis or malaria).*
Crowdsourcing (Lessl & Asadullah, 2011; Norman et al., 2011)	Public idea submission concept for targets and compounds, focus on researchers, young academics, startups. Facilitated through individual website or intermediary (e.g. Innocentive). Enables broader access to public idea pool, often about research target access with high public and ethical interest (HIV, neglected diseases). *Bayer Pharma has launched a crowdsourcing tool through www.grants4targets.com. Researchers from across the globe can submit promising new targets and Bayer Pharma gives support grants to further advance research on targets in very early stages and grants for more mature ideas; in any case, all IP remains with the applicant.*

Model	Description / *Example*
Licensing (Rogers, Maranas & Ding, 2005)	Prevalent in technologies (in- and out-licensing) and prevalent in IP complementary to ongoing research activities. Licensing provides access to proprietary technologies or external IP based on the idea that the buyer assumes development responsibility with upfront payment and optional royalties. *Platform licensing has become popular, covering several projects at a time with one technology, such as a Gilead-MacroGenics agreement granting Gilead access to the Dual-Affinity Re-Targeting technology for cancer projects.*
VC seed fund	Collaborative fund of venture firms and also healthcare firms, often government supported, to buy equity of biotech start-ups in seed / early phases. Refers to preclinical phases, even idea generation stages thus with specific risk due to difficult success predictability. *Mission Capital´s QB3 efforts in California are mainly focused on seed investments, combining capital and knowledge of various venture capitalists, pharmaceutical and biotech companies in the US.*
Development Tools	
Strategic partnership / alliance	A partnership covering multiple projects. Can cover joint research and fee for service, often with umbrella contracts and a long-term goal and relationship. A strategic partnership can even cover a collaborative innovation strategy (often with regard to one specific indication or asset) between the partners. *Bayer Pharma´s strategic partnership with the German Cancer Research Center (DKFZ) incorporating novel risk- and reward-sharing approach with financial input of EUR 1 million per partner per year, and joint project selection. (DKFZ, 2013)*
Development consortia	Close-interaction technology development consortia. Usually in precompetitive space and focused on technological issues. Multiple players: Corporates, health organizations and institutions, authorities, biotech, and academia. Also good for networking, gaining reputation, public funding. *Ablexis formed a pharmaceutical consortium with five members to validate the potential of technologies and provide access to a novel transgenic mouse platform for antibodies. While using the platform, the technology is further advanced through strategic co-work between the involved parties.*
Joint research / project-based R&D	Focused research in a project-based collaboration with complementary specific knowledge brought in from both / all partners. Collaborative IP generation, development of technologies or products under pre-defined goals, often with mutual stake. *Bayer and the Tsinghua University in Beijing, China established the Bayer-Tsinghua Joint Research Center, a 3 years joint research plan in the area of biomedical sciences, particularly focusing on structural biology.*
Joint Venture (JV)	One of the more traditional models in inter-firm partnering. Often created for commercial or late development purposes. However also created as semi-independent R&D joint ventures, which are controlled by two (sometimes more) parent companies who share the equity-based JV. Due to higher risk of sharing of proprietary knowledge between firms, joint ventures in R&D have decreased, while R&D partnerships or joint R&D have become more popular across industries (Hagedoorn, 1996). *Boehringer-Ingelheim (BI) has recently initiated an R&D and manufacturing JV with Zhangjiang Biotech and Pharmaceutical Base Development Co Ltd in China, where a biopharmaceutical R&D and manufacturing facility is being set-up (Yining, 2013).*

Model	Description / *Example*
Embedding scientists	Provide work space for scientists in physical laboratory space to enhance idea exchange between companies and academia. It enables proximity to scientific trends and technology and the identification of new business opportunities, and often considers positive image creation. *Pfizer´s Centers for Therapeutic Innovation across eight cities, where Pfizer scientists work alongside academics, e.g. $85m alliance with the University of California, San Francisco (Senior & Foster Licking, 2011).*
Lead user innovation (Demonaco & von Hippel, 2005; von Hippel, 1976; Lettl, 2007)	Lead user identification through online networks or key hospitals. Doctors and patients are in focus and the model has become popular in medical devices or off-label drug application and therapy development. *Through www.stoma-innovation.com the company Coloplast introduced an opportunity for stoma patients to share experiences and to develop innovative solutions on their own. Coloplast identifies innovative individuals on the platform and invites them for lead user projects off-line (Keinz, Hienerth & Lettl, 2013).*
Innovation ecosystems (Hienerth, Lettl & Keinz, 2013)	Innovation ecosystem leverage the broader landscape of partners (individuals, startups, capital providers, suppliers, corporates, crowd) and often include multiple partnerships or contracts considered and managed under one ecosystem umbrella to foster an aligned and clear innovation strategy rather than many individual or specific solutions. *Eli Lilly´s FIPNet – Fully Integrated Partnering Network – intends to follow an ecosystem-like approach to bring together external and internal ideas, external and internal capabilities and resources, as well as external and internal capital. All collaborative R&D efforts are therefore put in context of their ecosystem FIPNet (see Dahlem, 2012).*
Open source partnering (Munos, 2006; Maurer, 2008; Perakslis, Van Dam & Szalma, 2010)	Closely related to virtual research opportunities often web-based and related to bioinformatics, based on open sharing and generation of information and IP with collaborative benefits from outcomes. *In an open source mode across academia and leading pharmaceutical companies, initiated by the US National Center for Advancing Translational Services (NCATS), existing molecules have been released from pharma corporates for further research (NIH, 2012).*

As the examples in the table demonstrate, managers can utilize a huge variety of tools for partnering and open innovation. However, knowing those tools is only a further step in developing an open innovation strategy, which we will outline next.

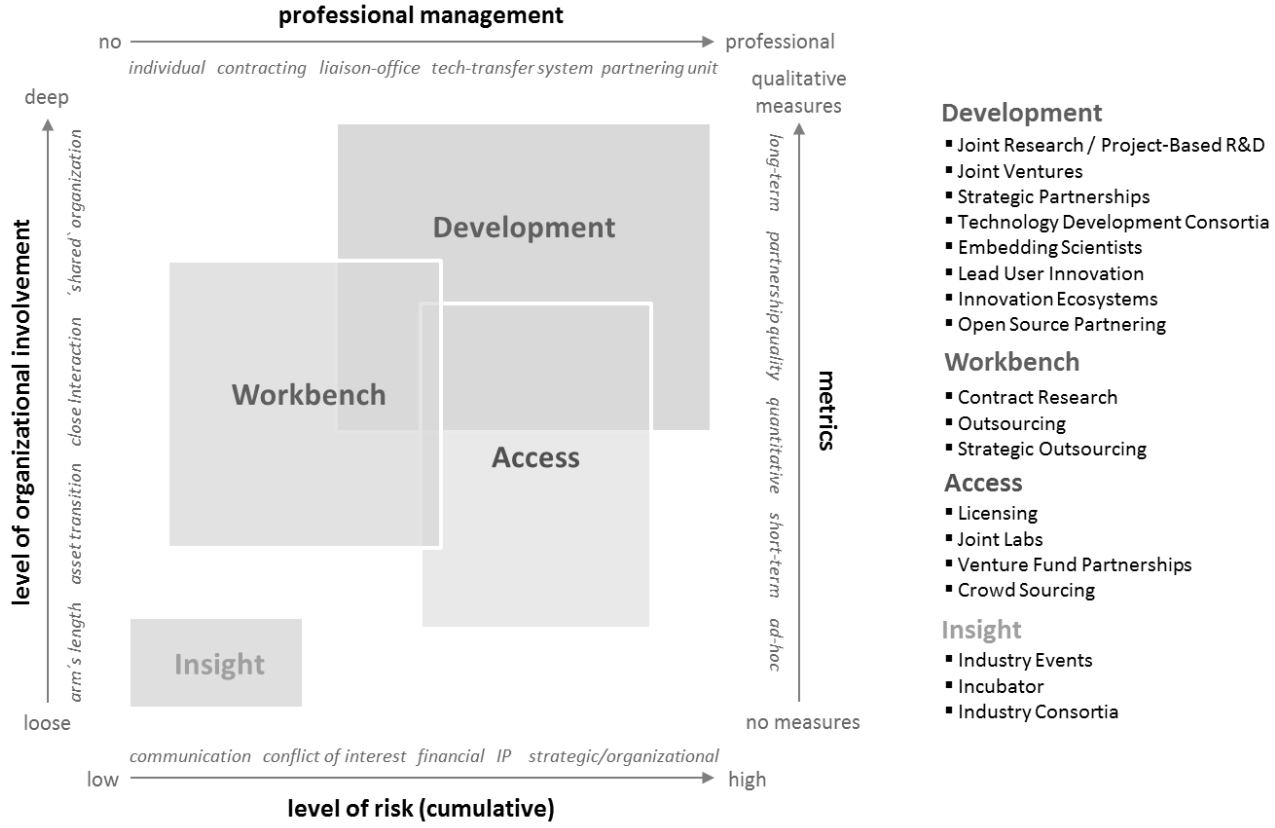
5 Discussion: Creating a Strategy

Our findings section has provided an overview about partners' and host-company perspectives on key elements enabling open innovation and collaboration management and we have generated a comprehensive list of different collaboration options available. Based on this, we discuss strategic implications in the next section.

Step THREE: Developing Strategy, Using the Open Innovation Matrix

Through our analysis we were able to describe strategy relevant patterns in open innovation within the biopharmaceutical sector. The open innovation tools are categorized into the four archetypes, resulting in strategy options for managers planning and implementing open innovation. The matrix in figure 6 shows the archetypes of collaborative innovation development and the associated four key elements presented in this study.

Figure 6: Archetypes and patterns of open innovation and collaboration tools



It consolidates the information from all data collected. On the axes it reflects areas of importance to partners (e.g. risk and outcome measurement) and to the parent/hosting company (e.g. level of organizational involvement). Regarding risk and performance measurement, interviews with the partner institutions revealed that external partners specifically look at the goals and intentions with

different open innovation tools while cautiously considering the overall risks. Furthermore, consequences for performance measurement seem to matter. For the host organization, the depth of organizational involvement and the requirements for professional collaboration management are certainly in focus, while risks and control options (metrics) have to be considered together with partners. The four different archetypes of collaboration across the matrix show that current innovation strategies of pharmaceutical companies lead to more complex ecosystem approaches. Whereas partnering-tools to cooperate for *access* or *development,* for example with smaller biotech firms, were indeed already present in the late 1970s (see Roijakkers & Hagedoorn, 2006), the variety and frequency of use of possible models for more sophisticated co-development have increased and pose respective challenges to the management of partners and tools involved in this "ecosystem". Many interview partners confirmed that they are moving towards more complex approaches through "*access to key technologies*", complete "*co-development of drugs*" (#30) and "*involvement in innovation and new strategies.*" (#18) What are some practical implications of these different approaches and choices?

- *Industry events* demand only very loose organizational involvement; they are usually not associated with severe risks, and outcomes are often not measured at all.
- In Contrast, *outsourcing* is usually associated with a certain level of organizational involvement due to the complementing of tasks within the R&D process. But risks are contractually manageable and outcomes are predominantly measured by clearly defined quantitative metrics. Management is often conducted individually through the R&D and procurement organization.
- Open innovation tools in the area of *access* (e.g. *venture fund partnerships*) are sometimes only associated with an "arm´s length", in other words: a marginal level of organizational involvement. However, they come with a more severe risk of disclosing information across involved

organizations: This risk needs to be managed with significant involvement of legal departments and hence affects the management of open innovation approaches across the company, which is turning more professional.

- ´On eye-level` development collaboration, which for instance usually includes *strategic partnerships*, sometimes with multiple partners, comes along with deep organizational involvement, a direct connection between the respective R&D functions and often a dedicated individual manager full-time responsible for the management of innovation tools. Organizational risks and intellectual property risks increase significantly while the outcome measurement by quantitative metrics would not adequately reflect the complexity and needs of the partnership. Therefore, partners set up qualitative outcome measures to evaluate partnership quality more profoundly.

Open innovation needs to be managed professionally when it takes place along all four archetypes of tools and in an ecosystem of various partners. This concluding discussion displayed in our matrix (figure 6) is further corroborated by our interviews with managers and researchers. We were able to figure out qualitative trends from our consolidated file of collected data: 1. Those companies or academic institutes who have defined success measurement well and have a clear perception about risk management and how to avoid major risks seem to have higher satisfaction in collaboration, whereas the ones who have more indistinct success metrics, e.g. "*answer scientific question*" (#17) and with lack of clarity on handling risks are apparently less often satisfied with collaboration outcomes. 2. Partners who have established professional management such as "*excellent partnership systems*" (#37) or a "*very good technology development office*" (#42) are apparently frequently successful in collaboration. They also seem to be open to look into more novel research and development areas together with partners, and to enter more strategic collaboration; those who had no professional management established or who were not using it to sufficient extent oftentimes

referred to severe issues and lower satisfaction with open innovation approaches. These partners seem to rather seek collaboration with companies who do have respective professional organizations in place – e.g. top pharmaceutical companies – as "*they are best organized*" (#51) and it is easier to profit from them. 3. Eventually, the firms and institutions with all key elements well established - deliberate organizational involvement, professional collaboration functions handling success metrics and risks - are apparently open to manage more sophisticated *development* and *access* collaboration tools, moving into "*early stages*" (e.g. #7, #13, #17) and foreseeing more strategic projects and partnerships (#22, #26, #29, #34); they would work within networked structures (ecosystems) and co-work with small (start-ups) as well as big partners; or even found "*collaborative start-ups around assets*" together with partners (#42).

In conclusion, considering the patterns of collaboration management proposed in this study and consciously selecting among the different open innovation tools is important when creating open innovation and collaboration strategy. We therefore emphasize some key insights for managers in the next section.

6 Managerial implications and recommendations

We suggest managers to evaluate their open innovation efforts according to the presented open innovation matrix (figure 6) and specifically refer to four dimensions when organizing their open innovation models: level of risk, metrics required to track the collaboration, professional management, and level of organizational involvement. This provides a basis to benchmark their organization with respect to the tools employed. Moreover, it seems to be important to consider the varying perception of different partners when innovating collaboratively, in our study represented by biotech companies, academic institutes, and contract research organizations – they seem to have partly differentiating needs in open innovation. Five core insights from our research can help better

designing open innovation strategies: 1. Deliberate choice of collaboration model: Managers need to ensure that the right **type of collaboration model** is chosen for the goal and intention of the partnership, e.g. whether to apply a strategic partnership or just a licensing possibility. It is important that the details of operation of respective collaboration models are well-known to the organization. The archetypes and tool-set can be considered to find the right focus. 2. Improvement of risk- and outcome measurement: Partners suggest to "*work on strategies that would allow longer projects and better planning.*" (#37) In order to do this, the understanding of the **level of risk** helps managers to better accomplish the underlying process of collaboration as it enables to identify which support (legal, negotiation, contracting, research-content etc.) within partnering processes is required. And the **measurement of outcomes** can improve the management of individual projects as well as the management of the portfolio of ongoing open innovation projects across archetypes. Both can also help in more "*rapid decision making*" (#11) requested by many partners. 3. Implementation of professional organizations: We recommend carefully considering the **level of organizational involvement** when applying open innovation tools, particularly when partnerships are conducted under the idea of collaborative concept development rather than complementary task accomplishment. Collaboration based on cooperative concept and strategy development requires **professionalized management** within the organization through dedicated alliance management teams to steer "*long-term strategic"* relationships (#46). These functions build up collaboration management skills, act as single-contact-hub to the partners and have responsibility to evaluate and measure the open innovation efforts. 4. Make external innovation efforts visible: Generate more **visibility** on open innovation projects across the organization and include these activities into the performance management and incentive-process of the R&D departments to enable a "*collaborative leadership structure*" (#11) and an "*open mindset*" (#24). Awards for collaborative work can further enhance culture for open innovation. 5. Design the value proposition: In more complex innovation

ecosystems under a global approach (#26) a **clear value proposition**, "*a platform to the outside*" (#9), for all participating organizations becomes more important. The goals of open innovation approaches as well as the offers for collaborations (areas, type of collaboration, and depth of co-work) should be clearly communicated.

7 Theoretical contribution and research outlook

Most of the prior articles on collaboration in the pharmaceutical industry have focused on specific forms of co-work such as outsourcing (Festel, Schicker & Boutellier, 2010; Sammons, 2000), licensing (Zebrowski, 2009; Rogers, Maranas & Ding, 2005), or in particular alliances (Eager, 2010; Laroia & Krishnan, 2005; Gomes-Casseres, 2000); many studies were practitioner-oriented. There is also a body of literature on the organization of external innovation – not specifically for the pharmaceutical sector – ranging from absorptive capacity theory (Cohen & Levinthal, 1990) to knowledge-based approaches (Almirall & Casadeus-Masanell, 2010; Laursen & Salter, 2006; Carlile, 2004) and organizational design concepts (Keinz, Hienerth & Lettl, 2013). The presented paper adds to this literature and the case-studies of alliance management, partnering and open innovation by providing an integrative view on the management and organizational patterns of working with different partners and through different collaboration methods and tools. We have carved out important managerial elements of collaborating, specifically with regard to partners and including their varying perceptions. And we have linked partner perceptions and key management elements to different archetypes of open innovation tools. This holistic perspective on the biopharmaceutical innovation landscape of partners and methods can be applied for further research on strategy and options of conducting open innovation. Having put the research focus on the broad collaboration environment of different partners and collaboration types existing around a large firm, it appears useful to further study open innovation management and -organization particularly

embedded within (open innovation) ecosystems. Research on business- and innovation ecosystems has been conducted around technology platforms (e.g. Xiaoren, Ling & Xiangdong, 2014; Markman, 2012; West & Wood, 2008), with market perspective (e.g. Velu, Barrett, Kohli & Salge, 2013), and from governmental or regional viewpoint (Ayrikyan & Zaman, 2012). Thus, the notion of ecosystems has been used rather widely, which certainly creates potential for further ecosystem research and for shaping the term with regard to open innovation, to which our article contributes. However our study is limited to a specific knowledge- and technology-intensive industry and conducted within the ecosystem of one single company. Future studies may apply our proposed concept in further qualitative and quantitative analysis, and also transfer the approach to other industries. More research in this field may also connect the key management elements and existing and emerging open innovation tools more precisely to organization theory and the particular impact on organizational design.

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