David against Goliath? Collaborative innovation in R&D partnerships of low-tech and high-tech firms. Empirical evidence from German industry

Full Research Paper

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Abstract

This paper presents empirical evidence for the innovation potential of asymmetric R&D collaborations between R&D intensive ("high-tech") and non-R&D intensive, respectively non-R&D performing ("low-tech") firms based on quantitative firm level data from German industry as well as a qualitative in depth firm case. Starting from an estimation of the overall economic relevance of "low-tech" industries in Germany based on macro- and microeconomic data, non-R&D-intensive firms' specific innovation paths and different innovation strategies will be discussed. This is followed by the analysis of their R&D collaboration activity. Our results show that there is a considerable gap between the potential benefit and actual intensity of R&D collaborations of non-R&D-intensive firms with research intensive collaboration partners. Besides the demonstrable advantage of such asymmetric R&D collaborations for the less research intensive partner – which is empirically measurable through significantly enhanced innovation performance compared to structurally similar, but non-collaborating firms - significant benefits can also be identified for the research intensive collaboration partner, as shown by the results of the case study presented in the paper. Such asymmetric collaborations could be much more often used and better exploited if the initially higher obstacles and barriers can be overcome. Besides its quantitative results, the paper also gives management recommendations for dealing with and overcoming such obstacles in asymmetric R&D collaborations.

Keywords: innovation, low-tech, R&D, collaboration management, absorptive capacity

The economic relevance of "low-tech" firms

Non-R&D performing and non-R&D intensive, so called "low-tech", firms and sectors have not been in the main focus of the R&D management discussion for a long time, given their -by definition -total lack, or very low levels of R&D efforts (Arundel et al. 2008; Cuervo-Cazurra and Un 2010). Latest research results show that these firms can be found to significant shares in all industrial sectors, including high-tech sectors (Rammer et al. 2011). Contrary to what could be assumed, they are not limited to a supplier position in the value chain, but are to equal shares suppliers and producers of finished goods, which means that half of the low-tech firms in Germany are competing on end markets and are thus directly affected by shifts in customer preferences and innovation pressures (Kirner et al. 2015). If the currently valid sectoral definitions of low-, medium-, and high-tech sectors (Legler and Frietsch 2007) are applied to the firm level, it becomes evident that low-, medium-, and high-tech sectors are composed of firms with very different levels of R&D intensity (Figure 1).

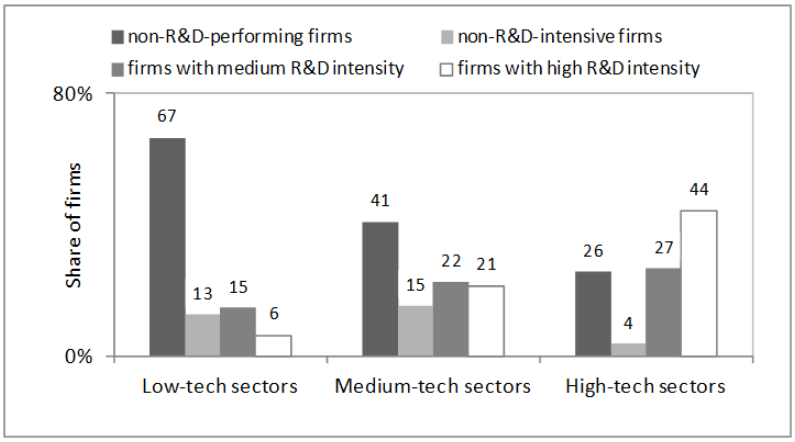

Figure 1: Distribution of firms with different levels of R&D-intensity within low-, medium-, and high-tech sectors. Source: German Manufacturing Survey 2012. (Kirner et al. 2015, p.81)

These results indicate a considerable intra-sectoral heterogeneity regarding firm-level R&D activity. This shows that the sectoral classification only partially reflects the actual R&D intensity of the firms belonging to certain sectors. As much as more than half of all firms in medium- and high-tech sectors are in fact not medium- or high-tech firms - if we look at their actual R&D spending. The intra-sectoral heterogeneity can be also demonstrated on NACE-sectors level, as shown in in Figure 2. Traditionally established research intensive sectors in Germany like manufacturers of machinery and equipment, the chemical industry or manufacturers of optical instruments have been and still are sectors with a surprisingly high share of so called low-tech firms - meaning non-R&D performing or non-R&D intensive firms. This, however, does not seem to influence the sectoral innovation performance negatively. Also, the share of low-tech firms is quite stable over time. An explanation for this phenomenon could be that low-tech firms occupy a key position in the respective sectoral value chain and contribute specific innovation relevant skills and competencies to the overall industry – despite their lack of R&D intensity (Kirner et al. 2009).

Innovation patterns of "low-tech" firms

Based on large-scale quantitative firm-level data, Som (2012) has demonstrated that non-R&D performing firms are following quite different innovation paths by using very different competitive strategies to reach sustained economic success. Some types of low-tech firms possess a profound level of technological absorptive capacity (Cohen and Levinthal 1990) which enables them to recognize, access and successfully adapt new – externally developed - technological solutions. Other types of low-tech firms make excellent use of their closeness to their customers and the ability to develop highly individualized

solutions very flexibly and reliably. Again, others show a knowledge-intensive, product innovation pattern that is closely related to that of R&D-intensive firms. This observed heterogeneity of innovation paths among non-R&D-intensive firms suggests that different firms make different strategic choices related to their innovation activities. This also could affect the respective relevance of different external information and knowledge sources. Some firms might consider customers´ feedback a central source of external knowledge, while other firms might establish close collaborations with research institutions in order to gain access to the latest technological developments – even if they are not intensively engaged in internal R&D themselves. R&D based and non-R&D based knowledge sources are both relevant for innovations (Som 2012, Lee and Walsh 2016).

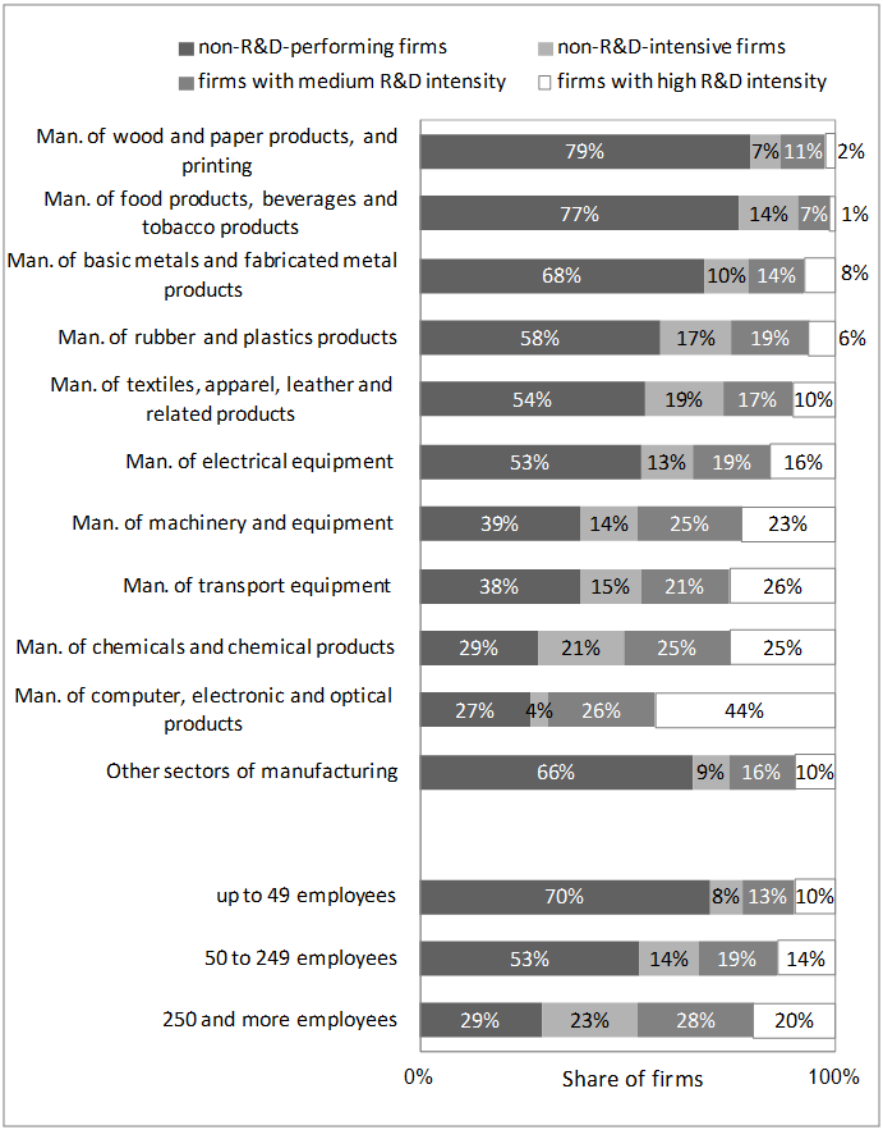

Figure 2: Distribution of firms with different levels of R&D intensity by sector and firm size. Source: German Manufacturing Survey 2012 (Kirner et al. 2015, p.83).

Absorptive capacity of "low-tech" firms

The original conceptualization of absorptive capacity of firms by Cohen and Levinthal (1989, 1990) encompasses the ability to recognize the value of new, external information, assimilate it and apply it to commercial ends. The absorptive capacity of a firm can be thus distinguished by two interdependent dimensions (Zahra and George 2002, Cassiman and Veugelers 2006, Arbussa and Coenders 2007): the capability to search and acquire new, external information about technological trends, and the capability to adapt internal processes and resource configurations in such a way that their competitive potential is fully exploited. The basic assumption is that those firms which manage external knowledge flows more efficiently, stimulate innovative outcomes and thus obtain superior competitive advantage (Escribano et al. 2009). Given that external sources of knowledge are becoming increasingly important for innovation, the capacity of firms to absorb relevant external knowledge is equally gaining relevance (Camsión and Forés 2010).

Although the original concept of absorptive capacity allows for a multidimensional understanding, many studies have linked absorptive capacity predominantly to firm`s R&D activities (Veugelers 1997, Oltra and Flor 2003, Leahy and Neary 2007, Therin 2007, Zahra and Hayton 2008). Internal R&D competences are believed to serve as an enabler for the firm's ability firstly to recognize external trends and developments in technology, secondly to evaluate them correctly, and thirdly to identify adequate solutions to implement such external technological developments successfully into the own enterprise. Hence, absorptive capacity is argued to be a cumulative result of internal R&D activities, suggesting that internal R&D capacity and practices of external knowledge sourcing are complementary to each other (Ebersberger and Herstad 2010, Schmiedeberg 2008) rather than substitutes (Chesbrough 2003). However, this understanding of absorptive capacity can be broadened. Authors like Murovec and Prodan (2009), Spithoven et al. (2010) or Escribano et al. (2009) emphasize that, against the backdrop of the systemic nature of innovation processes in which firms are embedded in social systems of multiple actors and forms of knowledge (Lundvall 1992, Foray 2006, Nooteboom 2009), the absorptive capacity of an enterprise should not be merely constrained to the recognition and implementation of R&D- or science-based knowledge. Thus, it is also important for firms to have the ability to recognise, evaluate and benefit from external developments, trends and information regarding their market environment and customers (Murovec and Prodan 2009, Escribano et al. 2009). Against this background, the absorptive capacity needs to be understood and measured as a multidimensional construct which encompasses both, science-based capacities as well as customer- or market-based competencies and resources that could be absorbed from external partners, e.g. strategic alliances, collaborations or networks with different stakeholders (Spithoven et al. 2010, Murovec and Prodan 2009). Following this line of argumentation advocating a more holistic understanding of firm´s absorptive capacity, four distinct aspects of absorptive capacity can be defined along the two main dimensions: a) science-based vs. customer-based, b) recognition vs. implementation (Som et al. 2013).

Both the successful recognition of relevant new trends and developments, as well as the implementation of new competences can be conceptualized as processes of organizational learning (Nonaka 1994, Cohen and Levinthal 1990, Jiménez-Jiménez and Sanz-Valle 2011). In terms or organizational learning, the two dimensions of recognition and implementation closely correspond to the two different types of learning: explorative vs. exploitative learning (March 1991, Bishop et al. 2011). Explorative learning takes place when a firm is able to identify, recognize and access new sources of information that are potentially relevant for its business. Exploitative learning occurs when this new information is being actually applied and implemented by the firm. Both types of learning, just as both types of corresponding absorptive capacity, are potentially equally relevant for innovation and competitive success. Given the above discussed heterogeneity among non-R&D intensive firms, R&D intensity is not assumed to be the main explanatory factor for the level and type of absorptive capacity. Instead, individual innovation paths and priorities are likely to affect the type and level of firms´ absorptive capacity, because firms will probably channel their efforts mainly into accessing and assimilating those types of external knowledge that they consider important. Empirical results based on telephone survey data from Germany confirm this assumption. Contrasting the different types (science-based versus customer-based) and different levels (recognition versus implementation) of absorptive capacity between R&D intensive (>7%) and non-R&D intensive (<2,5%) manufacturing firms, it can be shown that there is surprisingly little difference between "low-tech" and "high-tech" firms in their ability to absorb external source of knowledge - be it science-

based or customer-based knowledge – if the individual firm specific relevance of such external knowledge is being taken into consideration. Given that not all firms (be it R&D or non-R&D-intensive firms) compete on the basis of a first-mover strategy, there are significant differences to be found between firms as regards the individually perceived importance of the early adoption of new technological trends. Both R&D-intensive and non-R&D-intensive firms seem to be equally able to recognize and also successfully implement new technological trends, if this matches their competitive strategy and is therefore considered relevant. To explain the absorptive capacity of firms, the strategic importance of the respective type of external knowledge (science-based or customer-based) seems to be a better proxy than the mere R&D-intensity of firms.

However, the results also clearly shows that non-R&D-intensive firms have to undertake much more efforts to achieve a high level of absorptive capacity; in particular regarding science-based knowledge. While R&D-intensive firms still show a comparably high absorptive capacity of science based knowledge, even if the respective strategic importance of external science-based knowledge is weak, the corresponding absorptive capacity of non-R&D-intensive firms dramatically drops in this case. Hence, the availability of professionalised R&D-activities needs nevertheless to be considered as a strong enabler of firms' science-based absorptive capacity.

From a managerial perspective, this means that non-R&D-intensive firms have to take clear strategic decisions whether external science-based knowledge should be absorbed or not and - if so - to consequently devote considerable internal resources and implement organizational processes to build up and maintain such an absorptive capacity, for example through R&D collaborations (Som et al. 2013). Teirlinck and Spithoven (2013) have found that the propensity for a firm to engage in R&D collaboration is dependent on the internal R&D personnel potential to assimilate and manage external ideas and is also linked to the size of the SME. Thus, small, non-R&D intensive firms can be assumed to have a structural disadvantage regarding this possibility of absorbing external technological knowledge.

R&D collaboration in "low-tech" firms - status quo and future potential

Both low-tech firms with an already high level of technological/science-based absorptive capacity, and those with a close customer focus can potentially strongly benefit from engaging actively in R&D collaborations. Earlier findings based on data from German industry using Matched-Pair analysis have revealed that non-R&D intensive firms profit surprisingly strongly from R&D collaborations both with other firms (typically high-, or medium-tech firms) and research institutions. Collaborating low-tech firms show a statistically significant superior product innovation performance compared to those that do not engage in R&D collaborations (Kirner et al. 2010). This is mainly due to improved knowledge sourcing, and the advantages of risk sharing and cost reduction which a well-functioning R&D collaboration partnership can offer. Such collaborations can enhance the R&D related absorptive capacity of low-tech firms, assuming that firms with R&D collaboration experience will probably be better able to absorb further R&D related external knowledge than firms without any internal competences and experiences with R&D activities.

Given the large potential benefit of R&D collaborations for non-R&D intensive/low-tech firms, considerable room for improvement can be stated when looking at the actual collaboration intensity of these firms. There has been, and still is a large gap between the collaboration intensity of low-tech and medium-or high-tech firms - especially in the field of R&D (Som et al. 2015), just like there is between small and medium.sized or large firms (Teirlinck and Spithoven 2013). However, even if we take into consideration the effects of firm size (given that non-R&D intensive firms tend to be generally smaller than R&D intensive firms), there still remains a large unused potential for R&D collaboration between non-R&D intensive and R&D intensive firms. We might assume that the innovation benefit that can be seen in low-tech firms that engage in R&D collaborations only occurs if the R&D collaboration with an R&D intensive partner is working well – which is not at all self-evident, given the asymmetric nature of such collaborations. This kind of collaborations require the investment of an above average level of managerial resources, given the organizational and probably also cultural differences between the collaboration partners as well as the (tacit) knowledge based content of the collaboration (Hahn 2013; van de Vrande et al. 2009, Narula 2001). Furthermore, the level of technological and market diversification plays a role regarding opportunities and possibilities for technological alliances with external R&D

partners (Krammer 2016), which is typically not an easy to change circumstance. There is quite a deep structural, cultural and knowledge based gap between the two collaboration partners in such an asymmetric collaboration partnership, which first needs to be bridged and harmonized before any mutual benefit can be generated at all.

From an economic perspective, differences in company size and resources result in asymmetric information of agents as well as diverse motives for collaboration based on differences in firms´ bargaining power. Although both collaboration partners might have a strong interest in regulating the collaboration relationship by contracts, especially horizontal collaborations like R&D collaborations are by nature very difficult to regulate in advance (Nielsen and Sorensen 2008, Som and Zanker 2011). From an organizational design perspective this leads to the challenge to manage organizational interfaces between heterogeneous partners without the "help" of a bureaucratic, formalized structure - for which there is almost no in advance guidance available.

Barriers of and management implications for asymmetric R&D collaboration between low-tech and high-tech firms – a case study approach

The existence of these obstacles might stop many non-R&D intensive firms from even starting an R&D collaboration – which shows in the overall remarkably low R&D-collaboration rates of non-R&D intensive firms. At the same time, collaboration partnerships can only strive if both partners are able to benefit from it. The R&D intensive collaboration partner also needs to have a fairly clear vision of the potentially reachable benefit of such an asymmetric collaboration – that can outweigh the initially higher investment in coordination and communication that is required in such a collaboration compared to an R&D-collaboration between similar partners. Possible benefits for the R&D intensive partner could be getting access to a specific (niche) market, or getting access to a highly specialized (process) knowledge possessed by the non-R&D intensive partner, which through joint R&D efforts can be further developed and applied in a new context. The innovation benefit needs to be clear for both collaboration partners, if a collaboration partnership is to work out. This general necessity is particularly important in asymmetric collaborations between differently R&D intensive partners, because the barriers of initiating and maintaining such collaborations are considerably higher than in symmetric ones. Even though a higher intensity of these collaborations could be mutually beneficial for all collaboration partners, the reason why so few firms engage in them might be because either the collaboration barriers seem too high and the potential benefits too unclear to justify the efforts needed to start and coordinate such a "high maintenance" collaboration.

Understanding collaborative interorganisational relationships has become a major research area on the organisational and innovation research agenda. Institutional economists have analyzed this topic in terms of a comparison between alternative transactions and government structures. In case that neither the market nor the organizational hierarchy can be regarded as the most efficient mechanism of resource allocation, some degree of collaboration is a rational solution (Williamson 1979). Some management researchers focus instead on the resource-based view of the firm to explain the motivation and benefits of collaboration (Barney 1991; Dyer and Singh 1998). From another perspective, lawyers have focused on the contract that regulates the collaboration (Macneil 1980). Moreover, organisational sociologists have attempted to explain the formation and structure of collaborations depend on contingency factors in the surrounding ecosystem (Oliver 1990). However, most scholars have ignored the process level and it is often implicitly assumed that each collaborative relationship will more or less be characterized by some symmetry (Nielsen and Soerensen 2008). So far, asymmetry has been mostly recognized in terms of asymmetric information within collaborations (Reuer/Koza 2000). Asymmetries involved in collaborations between large and small organisations have been related to fragile relationships, because of their difficulties in providing fair dealing, convergent interests, and different competitive pressures or dependencies (Khanna et al. 1998; Ring et al. 2005). Following Nielsen and Soerensen (2008), asymmetry in this paper is used to label and operationalize inequalities and differences in several aspects of interorganisational relationships between non-R&D-intensive and R&D-intensive collaboration partners. According to the circumstance, that asymmetries between low-tech and high-tech firms are

caused by the difference in R&D-intensity, we apply a resource-based perspective (Barney 1991; Dyer and Singh 1998). Due to the lack of general definition of asymmetry dimensions, we structure asymmetries between non-R&D-intensive and R&D-intensive companies on the levels of i) industry/sector, ii) firm/organisation, and iii) individuals (Hahn 2013).

Firstly the sectoral affiliation of the collaboration partners: different industrial sectors are typically structured around different technological paradigms, shared assumptions and patterns of innovative behaviour (Malerba 2005). In consequence, the symmetry between firms located in the same sector or industry is expected to be higher compared to firms settled in different industries. Here, asymmetries exist in terms of different terminology, different mental models of problem solving, different technological bases, and different knowledge culture (Heidenreich 1997). Secondly, firm characteristics such as product complexity, production structure, export orientation and most importantly internal organizational structures and routines as well as the organizational culture are important sources of heterogeneity. High heterogeneity in these areas between innovation collaboration partners tend to result in serious problems regarding the definition of shared collaboration targets, joint work processes and the overall coordination of the collaboration activity. The third proposed source of heterogeneity can be found on individual level. This includes the individual competences and characteristics of the individuals who are directly involved in performing the collaboration. Their respective professional background and professional identity, work style and communication patterns have a significant influence on the quality of the collaboration. Heterogeneity between the collaboration partners in one of these three fields increases the complexity of the collaboration due to high coordination and negotiation requirements. It becomes quite difficult to establish a mutually beneficial and smooth collaboration, when too big differences need to be bridged. The risk of collaboration failure increases with higher levels of heterogeneity (Hahn 2013). Of course, it is still possible to establish agreements that reduce this complexity to a manageable level. However, this requires conscious and sustained effort. How such agreements could look like and which level of commitment to overcome the initial barriers is needed will be illustrated by the following case study.

Methodology

To identify and better understand the specific challenges of asymmetric innovation collaborations, the following case study maps out an R&D collaboration between a non-R&D performing, traditional medium sized firm from the textile industry (low-tech) and a large R&D intensive firm from the medical technology sector (high-tech), which - after being faced with initial difficulties and obstacles - has developed into a mutually beneficial R&D collaboration over time. This case study has been conducted in the frame of a larger research project (see also Som and Zanker 2011) and has focused on the specific barriers that are expected to occur in asymmetric innovation collaborations. According to the theoretical requirement of handling high empirical complexity and multiple variables simultaneously and the lack of previous (quantitative) studies on the firm-level that can be referred to – the paper decides for an explorative approach of empirical analysis in terms of qualitative case studies on the firm-level (Yin 2003). Besides the aforementioned questions, the paper also aims at opening up perspectives for future research. Therefore, a qualitative approach also helps to identify new perspectives which need to be included in future theoretical and (quantitative) empirical analyses of marketing and organisational innovation and innovation studies in general (King et al. 1994).

The applied mixed methodology combining interviews and an action research approach aims at contributing to theory building in the field of asymmetric R&D collaborations (Eisenhardt and Graebner 2007). Besides conducting several in depth interviews with individuals from different hierarchy levels (top management, department heads as well as employees on operative level) in the low-tech firm, the method of action research (Eden and Huxham 1996, French and Bell 1994) has been applied in form of a one day workshop that has been structured and lead by the research team. Several high level representatives from both the low-tech and the high-tech collaboration partner have met for one entire day with the aim to search for solutions for the – at that time – critical state of their collaboration. Researchers and practitioners have worked together during that workshop very closely in search for solutions for the collaboration problems. The researchers hereby focused mainly on structuring the problem and gaining further insights about typical collaboration problems in asymmetric collaborations

and their possible solutions, whereas the practitioners focused on reaching detailed and ready-to-implement agreements to solve the collaboration difficulties they were experiencing on a daily basis.

Setting the scene

The company is a manufacturer of metal parts for the textile industry. It is a traditional family owned and family managed company founded in 1859 located in the south of Germany, and employs approximately 80 employees at the headquarters as well as additional 20 employees at a production plant located in Eastern Europe. Core products of the company are small metal accessories in the fields of lingerie, foundation garments and beach fashion. Their competitive advantage is mainly based on their high vertical range of manufacturing which has been unique so far. It allows the company to achieve an outstanding volume and variant flexibility as well as high quality and quick reaction times. The customers are mainly manufacturer of luxury lingerie and clothing. The company's position in the industrial value chain up to this point was mainly being a specialised supplier in a niche market. Along these circumstances, the company is characterised by a complete lack of internal R&D activities (no R&D department, no R&D expenditures). The tasks of engineering and process development are instead located at the employees in production, particularly the head of production.

Due to the increasing cutthroat competition in the market segment, the management decided to open up new fields of business. Based on a personal observation of a family member of the CEO (lack of sufficiently stable medical/sports bandages on the market at that time, which could be solved by sewing in metal bars manufactured by the own firm), the medical industry has been identified as a promising area for collaboration. The goal was to transfer one of the core competences of the company into a product of the medical industry. For this purpose, the firm managed to successfully initiate an innovation collaboration with one of the world's leading manufacturers for orthopaedic devices; a truly R&D-intensive company with an institutionalised R&D department and a more than 7% share of R&D expenditures on sales with over 2000 employees.

The asymmetries

Firstly, asymmetries between these two collaboration partners can be found on the sectoral level. While the lowtech-company was located in the textile industry which is characterised by mainly productivity- and cost-driven competition, the R&D-intensive collaboration partner is affiliated to the medical industry. The latter is mainly characterised by technological leadership, the access to scientific knowledge and R&D-based product innovations. So while the dominant innovation mode in textile industry is about technical and organisational process innovations which are mainly based on the practical and tacit knowledge of the employees, the medical company was focussed on product innovation by using highly formalised scientific knowledge generated by intense inhouse R&D. Another asymmetry on the industry level can be found in the different requirements on technical documentation and standardisation in the medical industry. In contrast, the lowtech company so far almost did not have to meet such kinds of requirements. In consequence, the processes and know-how in this company were almost not documented or standardised at all.

Secondly, further asymmetries existed on the firm level. The lowtech company was characterised by a low level of hierarchy. The dominant mode was ad-hoc management. According to the missing R&D activities, an institutionalised innovation process with clearly defined tasks and responsibilities had never been established. Innovation projects were mainly inserted via the sales department (in terms of customer requests) and handled by production management and the top management. Because the company was so far mostly engaged as a supplier, the only defined communication interface towards external partners was established in the sales department. An organisational interface on the technological level was not existent until then. In contrast, the high-tech partner was structured along clear hierarchical levels with defined rules of communication, both inside the company as well as towards external innovation partners. One consequence of the different hierarchical firm structures was that a young graduate from university, who has just started his first job in the R&D department of the medical company, has been assigned as a

direct communication partner to the CEO of the low-tech company during the initial stage of collaboration.

Thirdly, on the individual level one asymmetry was reflected in the fact that the employees of the low-tech partner were neither familiar with the specific terminology, nor the established software tools and instruments of product development in the medical industry. They also lacked the formal education level (university degree) of the employees with whom they were supposed to collaborate directly. Additionally, high personal reservations prevailed against this newly initiated collaboration with the high-tech partner, especially among elder employees of the low-tech firm who did not recognize any potential benefits of a collaboration with a partner that is so different compared to the own company.

Due to these asymmetries the innovation collaboration quickly reached a critical status within the first year. Despite the low-tech firm's strategic goal to establish itself as an innovation development partner of the medical company, it found itself early being degraded to its usual supplier role instead of being involved into early stages of product development. One reason for this was that the high-tech company gained the impression that the professional level of the innovation activities at the side of the low-tech firm was not very high due to the lack of documentation and formalisation of knowledge. Additionally, the low-tech company was not able to open the CAD-drawings sent by the medical company as did not use CAD software in the past due to the missing product development. Secondly, as the R&D department of the high-tech company did not have a counterpart on the low-tech side, the stopped their respective inquiries already at an early stage, and their sole communication interface on the operational level remained that to the sales department of the textile firm. However, the head of sales was not able to answer the request concerning technical details. Thus, the low-tech company started to feel frustrated as they were not involved in any co-development processes, as they had hoped for. Moreover, on the personal level, whenever the CEO of the low-tech firm tried to reach the responsible person at the high-tech company, he was only connected to the university graduate what he perceived as lack of respect and as expression of the low priority the high-tech partner obviously attributed to this collaboration.

Lessons-learned for innovation collaboration management

Given these problems on multiple levels of the collaboration, both partners were ready to exit the partnership by the end of the first year. But they agreed on having a final attempt to save the situation in form of a one day workshop facilitated by a neutral mediator (the authors) within the frame of an ongoing research project on low-tech/high-tech innovation collaboration. As participants for this workshop both firms sent the relevant people who had been involved so far in the collaboration: the CEO, head of sales, head of production and two technicians from production from the low-tech firm, and the head of innovation management, head of R&D, head of purchase, head of sales and the head of quality management from the high-tech firm. The objectives of the workshop were: i) stocktaking of the collaboration,ii) defining the role(s) that should be played by the low-tech company in the medical partner's future innovation activities, iii) deduction of well-defined expectations and requirements resulting from the desired tasks and role(s) of each partner, and iv) establishing an agreement about practical measures and milestones to implement the necessary preconditions for a successful continuation of the partnership.

With regard to the definitions of the low-tech partner´s role in the innovation collaboration, it was agreed that they should not only act as a reliable "doer/supplier", but should also be involved as an initiator of innovation impulses at the early stage of the high-tech firm's product development process. Moreover, given their strong existing experience in the realisation of technical processes the low-tech firms was also desired to be a "sparring partner" for the high-tech company when it comes to the implementation of new ideas into series production.

Based on this agreement, the partner started to discuss how the existing solutions regarding the existing problems and underlying asymmetries could be solved. To do this, they started discussing based on concrete interactive problems experienced in the past by following a strict solution-oriented approach (i.e. no blaming for failures or mistakes). Therefore, based on the previously defined roles of the low-tech company, both partner stated their expectations and requirements regarding the operative interaction in

order to meet these roles. At the end, both partners agreed on a number of organisational measures to improve the processual and communicative interface between both companies:

Management measures to be taken by the low-tech collaboration partner:

- Ensurance of the technical communication compatibility in terms of setting-up a CAD-System for opening and modifying the electronic drawing documents of the high-tech partner.
- Systematic documentation and proactive communication of potentials for improvements and innovation impulses offered to the high-tech partner.
- Creation of professional innovation capabilities, e.g. institutionalisation of an innovation process management, regular meeting of the team "innovation" in the low-tech company.
- Establishment of a defined contact person ("boundary spanner") who has the overview of all relevant ongoing technical and organisational activities, and who takes the main responsibility for keeping schedules and milestones.

Management measures to be taken by the high-tech collaboration partner:

- Early and transparent communication of future product specification, product ideas and the future products' field of application towards the low-tech partner.
- Disclosure of the product development strategy to allow for early identification of future innovation collaboration potentials.
- Establishment of direct contact persons in the R&D department and the quality management department. For the low-tech CEO, the head of R&D of the high-tech partner offered to be the contact person (instead of the university graduate).
- Forwarding customer and end-user feedback to the low-tech partner in order to identify needs and options for improvement.

Joint measures to be taken by both partners:

- Establishment of regular and formal communication activities that encompass all relevant employees involved in the innovation collaboration (e.g. R&D, engineering, production management, quality management, purchase). These meetings should also be used to agree upon a shared terminology and increase mutual understanding for the working and innovation cultures of the partners.
- Definition and implementation of inter-organisational process operations.
- Definition of tolerances when defining tasks and requirements.
- Joint testing of prototypes.

After this workshop the collaboration process started to improve. Both partners have implemented the agreed changes and over a short period of time it was possible to jointly develop a new type of bandage with higher stability that has become quite successful on the market. Making the asymmetries transparent during this workshop, and consciously searching for organizational and processual measures to bridge them helped to find a mutually satisfying solution for the collaboration problems resulting from the high level of asymmetry. The low-tech firm has become a strategic development partner of the high-tech firm and is now an A-grade supplier.

Conclusions

Non R&D intensive firms are an important economic factor and contribute to the innovation system in multiple ways. They play a relevant role in the value chain in all sectors. Many of them are innovators, but they are following quite different innovations paths. However, there is a structural disadvantage they face when it comes to science-based, technological innovations which require R&D based knowledge. This disadvantage could be successfully compensated through engaging in collaborations with R&D intensive partners. There is potentially a high benefit to be gained for both R&D intensive and non-R&D intensive partners in such collaborations. Many low-tech firms have close relationships with their customers and are highly specialized in their market niche. Their (often tacit) process and market knowledge can be of great benefit for R&D intensive collaboration partners, who in turn can contribute lacking resources and technological competences to the collaboration. The reason why so few low-tech firms engage in such collaborations with R&D intensive partners can be assigned to the high level of asymmetry that these collaborations are characterized by. Bridging these asymmetries thus seems to be a key success factor.

The case study presented in this paper highlighted the risks and challenges connected to the asymmetries that occur in a typical low-tech – high-tech innovation collaboration. It has been shown that managing for such collaborations needs extra efforts in the design and coordination of inter-organisational interfaces to deal with these asymmetries. One of the most important success factors is transparent, regular and thorough communication. Both partners need to resist thinking that the collaboration could somehow find its own "rhythm" over time. Given that sectoral innovation patterns, organizational structures, individual competences and the overall innovation culture tend to strongly differ between the collaboration partners of such an asymmetric collaboration, there is almost no mutually shared common base to rely on. From a managerial perspective, communication and operative processes need to be backed-up with explicitly and consciously defined organisational boundaries and procedures. This requires additional negotiation and coordination efforts that can be regarded as a necessary investment in such a "high maintenance" collaboration. Both partners need to be willing to assure that their existing organisational interfaces are adapted in such a way that they can the bridge the high level of cultural and behavioural differences that are rooted in the inevitably high asymmetry between low- and high-tech firms. Only if both partners are willing to contribute this investment, does the collaboration have a realistic chance for success.

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