Professional MBA

Entrepreneurship & Innovation

The influence of top management, innovation- culture and organization on open innovation, its impact on innovation success and cross sectoral learnings from benchmarking of an Austrian Biotech firm against a group of German companies

A Master's Thesis submitted for the degree of

"Master of Business Administration"

supervised by

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Tulln, 25.06.2018

Affidavit

I, **GERD SCHATZMAYR**, hereby declare

1. That I am the sole author of the present Master's Thesis, THE INFLUENCE OF TOP MANAGEMENT, INNOVATION- CULTURE AND ORGANIZATION ON OPEN INNOVATION, ITS IMPACT ON INNOVATION SUCCESS AND CROSS SECTORAL LEARNINGS FROM BENCHMARKING OF AN AUSTRIAN BIOTECH FIRM AGAINST A GROUP OF GERMAN COMPANIES, 85 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool and
2. That I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad

Vienna, 25th of June, 2018

…………………………………………

Signature

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Abstract

In today's industrial environment open innovation undoubtedly is a key factor which contributes to innovation success. Although the concept of open innovation (OI) was published fifteen years ago, many companies still struggle with the implementation of this promising paradigm of innovation. The goal of this thesis was to investigate possible influencing factors of the innovation system on OI and to evaluate if the implementation of OI leads to innovation success. The analyses were performed with data from more than 30 German companies (peer group) which were provided from a larger survey at University of Economics, Vienna (WU). Moreover, an Austrian Biotech firm was benchmarked against the peer group, in order to assess its innovation management system and to deviate learnings from this cross sectoral comparison. In a first step, the peer group was characterized regarding implementation of short- and long term OI activities. It turned out that only 28% of these companies belonging to different industrial sectors fully adopted OI. Statistical analysis did not show any significant influence of innovation supportive management and innovation culture on the engagement in OI. This result, which is in contradiction to many literature studies, points to the fact, that the number of companies involved in this study might have been too small. Furthermore, the companies were quite heterogeneous concerning their size (between 45 and 11,300 employees) and their affiliation to different industrial sectors. However, it could be observed that an implemented formal innovation management system positively correlates with adopting OI methods and activities. Although the engagement in OI was rather low in the peer group, a statistically significant effect of implementation of OI on innovation success based on revenues with newly developed or improved products could be seen. No significant impact was seen on engagement with OI and revenue growth during the past four years. More than 100 questions belonging to 16 categories were analyzed during the benchmarking. The Biotech firm achieved a better ranking in eight categories and the peer group in average performed better in five categories. For three categories no differences could be observed. Furthermore 22 questions regarding tools, methods or behaviors were identified where the peer group in average achieved a higher ranking. Out of these 22, six questions were ranked very important for a follow up in order to improve the innovation management system of the Biotech firm. Possible improvements were suggested for those areas, for which the ranking was below the peer group.

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Abbreviations

BSC	Balanced scorecard
CEO	Chief executive officer
CIS	Community innovation survey
EUR / €	Euro
HR	Human resource
I	Importance
IMP	Innovation management process
IP	Intellectual property
IS	Innovation strategy
IVP	Innovation process
Mio	Million
NA	Not analyzed
na	No answer
NA	No answer
NIH	Not invented here
N°	Number
NPD	New product development
NPV	Net present value
NSH	Not shared her or not sold here
OI	Open innovation
PR	Pearson's correlation coefficient
PwC	Pricewaterhouse Coopers
R&D	Research and Development
rlm	Robust fitting of linear models
RQ	Research question
SR	Spearman's correlation coefficienct
T-MGMT	Top managment

1. Introduction

1.1 Problem formulation and relevance of this research

Globalization raises competitiveness and this increasingly forces enterprises looking towards innovation in order to offer differentiated goods and services as well as lower costs for meeting their long term business objectives (Porter, 1998). Innovation is therefore central to the development and maintenance of new products, new ways of working and new processes within any organization (Radnor and Robinson, 2000).

Innovation is a complex activity including different processes which have to be coordinated and managed. A proper application of innovation management techniques facilitates a company's ability to introduce appropriate new technologies in products or processes, as well as necessary changes in the organization. However, most companies do not have an innovation culture that favors the introduction of change within the organization, more often there is a strong resistance from staff and sometimes from management (Hidalgo and Albors, 2008).

A major focus in this study will be put on open innovation (OI) activities, because environmental uncertainty, the complexities of innovation and knowledge recombination have led to increased permeability of organizational boundaries and the need for organizations to interact with their environment and external stakeholders in more open ways (Felin and Zenger, 2014).

The OI concept was first described by Henry Chesbrough in his book "*Open Innovation – The New Imperative for Creating and Profiting from Technology*" (Chesbrough, 2003b). "Open innovation means that valuable ideas can come from inside or outside the company and can go to the market from inside or outside the company as well". It has been reported that a proper implementation of OI increases product performance and leads to a financial advantage for organizations (Faems et al., 2010, Enkel et al., 2009). However, the change process from closed to open innovation is rated as a difficult task (Chesbrough and Brunswicker, 2013). Although the era of open innovation has begun for many firms, we still lack a clear understanding of the mechanisms, inside and outside of the organization, when and how to fully profit from the concept (Enkel et al., 2009). Therefore it is of great interest to generate more and updated information on open innovation activities and performance. Factors which prevent firms from being open are a lack of market and technological knowledge (knowledge gaps), ineffective intellectual property (IP) protection mechanisms, and competitor threats such as market entries and imitation (Drechsler and Natter, 2012). Besides these factors a significant organizational and cultural change is needed to adopt OI (Dodgson et al., 2006). Especially the latter ones seem to be crucial, because the willingness of management and employees appear to be the basic requirement for adopting OI. To prove this hypothesis a model was established which assumes that an innovation supportive top management (T-MGMT), a certain innovation culture and the proper organization of the innovation process positively influence open innovation activities and this subsequently leads to an improved innovation success (Figure 1).

In this study it will be tested if this model applies to German companies belonging to various industrial sectors. The basis of this thesis are data obtained from an innovation survey with 38 German companies.

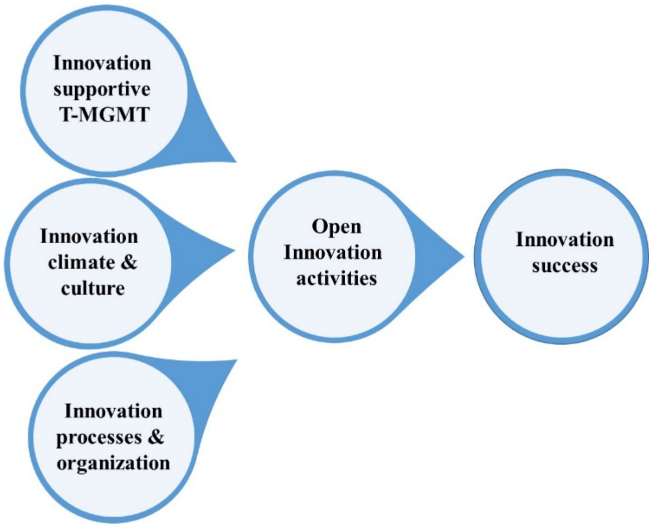

Figure 1: Model with main categories covered by the questionnaire in the innovation survey

Furthermore the OI concept is particularly important for firms in the biotech industry, as this industry is moving to a more collaborative approach in innovation due to the high product developing costs. Biological science is becoming so complex that no one person, laboratory or company can effectively dominate the knowledge space, leading to the believe that breakthrough innovation will only come through partnerships (Nakagaki et al., 2012). This study therefore also aims to investigate current OI practices based on data provided by an Austrian Biotech firm. Furthermore the innovation management system (IMP) of this biotech firm will be benchmarked against the German companies ("peer group") in order to derive any cross sectoral learnings. The benchmarking method was used for this part of the thesis, as this method is clearly related to the idea of finding inspiration from outside the organization. It is the process of learning from others and involves comparing one’s own performance or methods against other comparable organizations (Slack, 2016).

1.2 Research questions

The implementation of OI seems to be crucial for the success of organizations in this rapidly changing economic environment. However, it still seems to be difficult for organizations to implement OI, although this paradigm had already been described 15 years ago. This study wants to contribute with current information regarding factors which influence use and implementation of OI. Therefore the focus of this study is to investigate if factors such as management, innovation culture and the organization of innovation positively influence OI activities in organizations. Furthermore, the hypothesis that engaging in OI activities improves innovation success will be checked. This leads to the definition of the first research question (RQ1):

> **RQ1**: Are open innovation activities in the peer group facilitated by an innovation supportive management, the innovation climate or the existence of a formal innovation system and does the implementation of OI correlate with innovation success criteria?

A second objective is to generate more information on the adoption of OI in the biotech field based on the case of an Austrian biotech firm. Additionally, the IMP of this firm will be benchmarked against the German companies in order to generate new information and support cross sectoral learning. Based on results of the benchmarking concrete recommendations for improvements will be derived. Therefore the second research question (RQ2) can be defined as follows:

> **RQ2**: What are the major differences between the innovation management processes of an Austrian Biotech company and a sample of German companies in a benchmarking study? To which extent is OI implemented in the biotech firm? Which concrete recommendations can be derived from the benchmarking in order to improve the innovation management process of the Biotech firm?

1.3 Structure of this thesis

After the preface and the **introduction** (chapter 1), which contains problem formulation, relevance of research and research questions this thesis continues with a **literature** part (chapter 2) consisting of a general description of innovation followed by an explanation of OI and the importance of management and organizational culture on innovation. The literature part of the thesis concludes with a summary on information relevant for the topic of innovation success, possible measurements and the relevance of benchmarking.

Chapter 3 describes the **methods** used in this study. It is structured in an explanation of the research design, the data collection method based on a questionnaire and the respective statistical analysis and graphical presentation of the results.

In chapter 4 detailed **results** of this study are presented – on the one hand results from correlation and regression analysis (RQ1) and on the other hand results from the benchmarking studies (RQ2).

In chapter 5 (**discussion and future prospect**) results are discussed with literature information and conclusions are drawn. Possible improvements as results from the benchmarking are suggested.

The thesis concludes with chapter 6 in which **theoretical and practical limitations** of the results are discussed. This chapter concludes with a proposal on further research.

2. Literature

2.1 Innovation and innovation models

Innovation has been described in different ways by various scholars, for instance it was defined as the development and implementation of new ideas by people who over time engage in transaction with others within an institutional order (Van de Ven, 1986). Roberts came up with a simplified definition, namely "Innovation = Invention + Exploitation" (Roberts, 1988). He states that "the invention process covers all efforts aimed at creating new ideas and getting them to work. The exploitation process includes all stages of commercial development, application and transfer, including the focusing of ideas or inventions towards specific objectives, evaluation those objectives, downstream transfer of research and/or development results and the eventual broad-based utilization, dissemination and diffusion of the technology-based outcome". Melissa Schilling defines innovation in her book *Strategic Management of Technological Innovation* as "the practical implementation of an idea into a new device or process" (Schilling, 2016). These explanations show that multiple steps are needed for the realization of an idea into a service or product into the market and that for an efficient realization of the idea these steps need to be structured in a process. Based on scientific literature analysis the innovation process can be considered as an organized and controlled sequence of activities where inputs in form of innovation ideas are transformed into outputs in form of innovations. It is a process of recognizing customer needs and innovation opportunities, generating innovation ideas and their elaboration, work with information and knowledge regarding innovation, realization of innovation activities and ensuring successful extension of innovation among customers (Lendel et al., 2015).

In closed innovation systems, employees within the organization develop the ideas internally and in secrecy (Chesbrough, 2003b). A new sixth generation of innovation models can be called open innovation models. The concept of open innovation (OI) was first termed by Henry Chesbrough (Chesbrough, 2003b). One of the most obvious benefits of OI is the much larger base of ideas and technologies from which to draw to drive internal growth. But beyond that, leading companies also recognize open innovation as a strategic tool to explore new growth opportunities at a lower risk[1].

[1] http://venture2.com/wp-content/uploads/2016/03/Primer_on_open_Innovation_Visions_April06.pdf

2.2 Open innovation

As mentioned in the section before, there is a fundamental shift in how successful companies generate new ideas and bring them to the market. In the old model of closed innovation, firms adhered to the following philosophy: *Successful innovation requires control*, in other words, companies must generate their own ideas that they would then develop, manufacture, market, distribute and service themselves (Chesbrough, 2003a). Since 2003 OI has become one of the most importing topics in innovation management. A search in Google Scholar reveals 3.5 million hits for the term “open innovation” and Henry Chesbroughs’ book (2003) has gathered more than 5,100 citations. This is a significant increase compared to the data from July 2010 when 2.5 million hits in Google Scholar were found and the book had been cited 1,800 times (Huizingh, 2011)

Furthermore a search for OI literature on Science Direct[2] reveals that in the last decade there had been an enormous increase of scientific publications with 475 papers in 2017, whereas the plateau has not been reached yet (Figure 2). This shows the ongoing interest of academia and industry on better understanding and implementing OI principles.

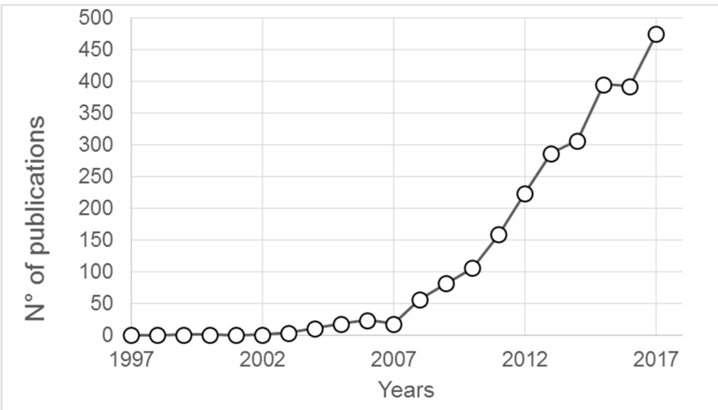

Figure 2: Development of number of publications in the field of Open Innovation between 1997 and 2017 - based on a search in Science Direct with subsequent analysis

“Referring to the organizational culture the literature has identified two syndromes that companies must overcome to facilitate the adoption of this emerging model. First, distrusting the quality, availability and capacity of ideas of others and, second, the tendency to monopolize the use of their innovations only within their own business” (Rodríguez et al., 2015). “Therefore, the companies studied have implemented a number of practices such as promoting OI throughout the organization, staff training on issues related to communities

[2] https://www.sciencedirect.com/

and networks, hiring empathic and entrepreneur staff of different backgrounds and encouraging employee participation in innovation processes". There are further reasons supporting the OI concept, like the superiority of groups over individuals. In an analysis of over half a million patented inventions it was found, that individuals working alone, especially those without affiliation to organizations, are less likely to achieve breakthroughs and more likely to invent particularly poor outcomes (Singh and Fleming, 2010). "Another fact is that not all smart people work for us. We need to work with smart people inside and outside our company" (Chesbrough, 2003b). In other words this means that collaboration with research institutes, suppliers and customers along the product development is considered in order to overcome high research and development (R&D) costs and lack of skilled people or knowledge inside the company. A starting point for the idea of openness is that a single organization cannot innovate in isolation (Figure 3). It has to engage with different types of partners to acquire ideas and resources from the external environment to stay abreast of competition (Chesbrough, 2003b, Dahlander and Gann, 2010).

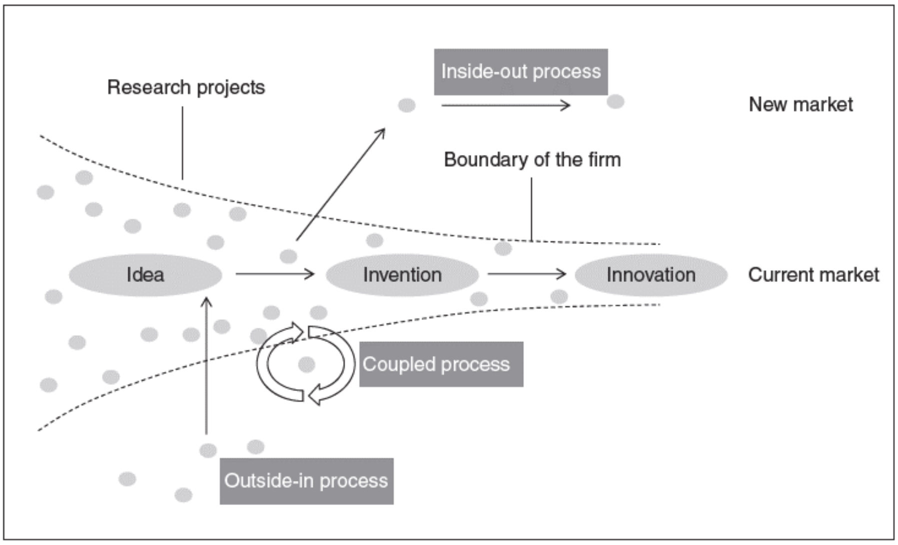

Figure 3: Open innovation process taken from (Brau et al., 2013), which is based on (Chesbrough, 2003b, Gassmann and Enkel, 2006)

"Open innovation thinking changes especially the role of the research function. It expands the role of internal researchers to include not just knowledge generation, but also knowledge brokering. Previously, researchers simply added to the knowledge sitting in the silos. Today, they are also charged with moving knowledge into and out of the silos. In this new role, knowledge located from outside may be just as useful as knowledge created from within and it should be similarly rewarded" (Chesbrough, 2003b). For the adoption of open innovation practices in particular, two of the most significant attitudes are the negative attitude towards the utilization of external knowledge (i.e. the not-invented-here (NIH) syndrome) and the negative attitude against the external exploitation of knowledge assets (i.e. the not-shared-here or not-sold-here (NSH) syndrome) (Burcharth et al., 2014). This concept can be extended to the R&D environment, where scientists like to prove hypotheses of other scientists which lead to the repetition of already published experiments, which is not always seen to be an effective way for new product development (NPD) in a commercial environment. While adopting the OI concept, R&D staff might fear to become obsolete if R&D activities are outsourced. Chesbrough, however, didn't have the abolishment of he internal R&D-department in his mind but rather defined a new rationale for internal R&D and supports the necessity of it with the following (Chesbrough, 2003b):

- "To identify, understand, select from, and connect to the wealth of available external knowledge"
- "To fill in the missing pieces of knowledge not being externally developed"
- "To integrate internal and external knowledge to form more complex combinations of knowledge, to create new systems and architectures"
- "To generate additional revenues and profits from selling research outputs to other firms for use in their own system"

By opening up to the outside, a company can get access to technologies that its internal research organizations won't create. "Research takes a long time to deliver useful outcomes, and company strategies change at a faster rate than the rhythm of basic research" (Chesbrough, 2003b). Furthermore in-house R&D is crucial to build the absorptive capacity which enables the organization to evaluate the external know-how which eventually needs to be insourced ("inbound innovation"). Different forms of open innovation have been described (Dahlander and Gann, 2010). "Outbound innovation / revealing, outbound innovation / selling, inbound innovation / sourcing and inbound innovation acquiring". "Laursen and Salter (2006) first introduced the concept of external search breadth and depth to measure the level of open innovation adoption. Breadth is defined as the number of external sources or search channels that firms use for their innovative activities. External search depth is the extent to which firms draw from these external sources. While external search breadth is a binomial scale (0 for not used, 1 for used) with 16 items (= sources), external search depth is measured on a four-point scale (from 0 to 3), but only high usage (3) is counted as a deep use of the source" (Laursen and Salter, 2006, Schroll and Mild, 2012). Lichtenthaler and Ernst (2009) grouped the respondents in their survey on open innovation into different clusters: Cluster 1 refers to the *defensive closed innovator* (very limited external technology acquisition and exploitation). Cluster 2 comprises a relatively large group of firms which are *defensive technology acquirers* (acquire technologies from external sources but limited degree on external technology commercialization). Cluster 3 is the *reserved technology acquirers* that rely very strongly on external technology acquisition, but external technology commercialization is limited. Cluster 4 is characterized as *reserved technology sellers*, as the focus is on internally developing new technologies and to actively commercialize technological knowledge in addition to their product business. Cluster 5 comprise the *aggressive proprietary innovators*. They follow both types of technology transaction to a certain extent, but focus on developing new technologies in-house and on commercializing them in their own products. The last cluster has been defined as *aggressive open innovators*, because these firms make use of external knowledge by strongly relying on external technology acquisition. Simultaneously, these firms do not only apply their technology assets in their own products, but they attempt to fully capitalize on their technology portfolios by additionally commercializing technological knowledge. In their study 52.6 percent of firms belonged to clusters 1 and 5 which pursue relatively closed approaches of innovation. 29.22 percent of firms belonged to the clusters 2, 4 and 6, which have considerably opened up their innovation process at least in one direction. 18.18 percent of firms have opened up the innovation process to a limited extent in the direction of technology exploration (cluster 2). Taken together in total 47.4 percent of companies have implemented OI in their business (Lichtenthaler and Ernst, 2009). In a study from Spain, a different categorization approach for OI adoption was used. Data from 10,875 companies belonging to small-, medium- and large- sized enterprises were collected and analyzed. Three categories toward OI were defined. *Open innovators* are firms with innovations developed mainly through collaboration with other entities or mainly by other entities. *Semi-open innovators*, are firms whose innovations were developed mainly through in-house efforts, but having cooperated or bought external R&D. *Closed innovators* are firms whose innovations were developed mainly through their own efforts and which have neither cooperated nor bought external R&D. Based on these definitions, 20.6 percent of firms are open innovators, 34.8 percent are semi-open innovators and 44.5 percent are closed innovators (Barge-Gil, 2010). A 2013 executive survey “Managing Open Innovation in

Large Firms[3]" found that 78 percent of firms reported practicing open innovation. The survey included American and European organizations with annual sales in excess of US$ 250 million (Chesbrough and Brunswicker, 2013, Chesbrough and Brunswicker, 2014). Their study also revealed that the OI adoption rate varies between different industries – from 40 percent in low-tech manufacturing to more than 90 percent in high-tech manufacturing (Figure 4).

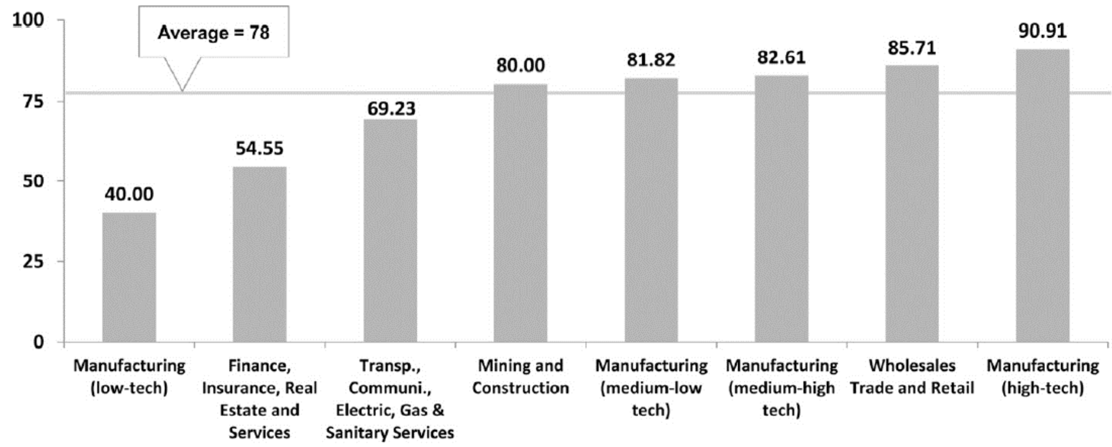

Figure 4: Adoption of open innovation by industry in percent (Chesbrough and Brunswicker, 2013, Chesbrough and Brunswicker, 2014)

The study also showed that large firms were spending US$ 2 million annually on OI and had 20 employees full time to run such programs. It was also found out that none of the firms in their sample report abandoning their practice of open innovation and 82 percent report that compared to three years ago, OI is practiced more intensively today. Moreover, it was reported that inbound open innovation practices are more commonly used than outbound practices as the share of projects with an inbound component is 35 percent on average and only about 8 percent of projects result in outbound activities. This study also confirmed that the biggest challenges in managing open innovation are within the firm.

Several tools and methods of been described to facilitate OI activities, such as cooperation with innovation intermediaries, use of focus groups, user communities, lead-user method, crowdsourcing, toolkits for user innovation and hackathons (Chesbrough, 2003b, Keinz et al., 2012). Furthermore collaboration with suppliers, universities and start-ups have become increasingly important (Tether, 2002). Van Hippel describes "how **lead users** can be

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[3] http://openinnovation.gv.at/wp-content/uploads/2015/08/Fraunhofer-2013-studie_managing_open-innovation.pdf

systematically identified, and how lead user perceptions and preferences can be incorporated into industrial and consumer marketing research analyses of emerging needs for new products, processes and services" (von Hippel, 1986). "Lead users are users, whose present strong needs will become general in a marketplace months or years in the future. Since lead users are familiar with conditions which lie in the future for most others, they can serve as a need-forecasting laboratory for marketing research. Moreover, since lead users often attempt to fill the need they experience, they can provide new product concepts and design data as well" (von Hippel, 1986). Jeff Howe defined the concept of **crowdsourcing** as an emerging phenomenon of the outsourcing of various activities by companies to an undefined generally large group of people on the internet in the form of an open call (Howe, 2006). Although this process has long been limited to the computing sector, it currently tends to cater a wider number of sectors. Firms use this process in order to outsource activities for limited financial compensations that cannot be completed by their own employees or are considered too costly in terms of manpower, finances and time (Digout et al., 2013). Also **user communities** have developed out from open-source software programming. In this concept the individual user does not have to develop everything on his own but, can benefit from others' freely shared innovations (von Hippel E, 2001). "**User toolkits** for innovation were recently proposed as a means to eliminate (costly) exchange of need-related information between users and manufactures in the product development process. The method transfers certain development tasks to users and thereby empowers them to create their own desired product features" (Bo, 2005). The application of above mentioned user innovation strategies facilitates the shift from a producer-centered internal innovation process towards a user-centered open innovation process. However, challenges will come along during this transformation and therefore meaningful frameworks and guidance for managers to master this transformation will be needed (Keinz et al., 2012). Also innovation brokers, who are **intermediaries** in innovation networks, can facilitate the innovation process. Innovation brokers have been defined as organizations that act in a liaison role between the sources of new ideas and the users of those ideas in innovation networks and are also set up specifically to perform this broking role (Winch and Courtney, 2007). However, also knowledge-intensive business service firms and research and technology development organizations can act as intermediaries in the innovation process. **Hackathon** is another open innovation method. Originally it was an event in which computer programmers and others involved in software development collaborate intensively over a short period of time on software projects. These hackathons are encouraging experimentation and creativity and can be challenge orientated.

Today, hackathons bring people from various backgrounds together for problem-solving. They are typically organized as intense, short-duration competitions where teams generate innovative solutions. The hackathon model integrates collaboration, idea generation and group learning by bringing together different stakeholders in a mutually supportive setting (Angelidis et al., 2016). Networking and cooperation with suppliers and competitors could also improve the OI performance of an organization. "A recent study provides evidence that network relationships with suppliers, customers and intermediaries such as professional and trade associations are important factors influencing innovation performance and productivity" (Pittaway, 2004). "Risk sharing, obtaining access to new markets and technologies, speeding products to market, pooling complementary skills, safeguarding property rights when complete or contingent contracts are not possible and acting as a key vehicle for obtaining access to external knowledge, were identified as the principal benefits of networking on business level". In a UK study investigating the pattern of cooperation between innovating firms and external partners it was found that firms engaging in R&D and attempting to introduce higher level innovations, i.e. 'new to the market' rather than 'new to the firm' innovations - are much more likely to engage in co-operative arrangements for innovation (Tether, 2002). Data about the service sector from the 4th Community Innovation Survey (CIS) were taken and analyzed. Results showed that firms provided with information from market sources and from internal sources as well as firms involved in science-based collaboration for their product innovations are more likely to introduce new to the market innovations, whereas information coming from competitors seems to have a negative effect on the degree of the novelty of innovations (Mention, 2011). In a study on cooperative R&D and firm performance in the Netherlands it could be observed that competitor and supplier cooperation focus on incremental innovations, hence improving the productivity performance of firms. University cooperation and again competitor cooperation are instrumental in creating innovations generating sales of products that are novel to the market, improving the growth performance of firms. Furthermore, customers and universities are important sources of knowledge for firms pursuing radical innovations, which facilitate growth in innovative sales in the absence of formal R&D cooperation (Belderbos et al., 2004). Another study focused on the effect of business – university alliances on innovative output and financial performance. Based on an analysis of 2,457 alliances undertaken by 147 biotechnology firms it could be seen, that companies with university linkages have lower research and development expenses, while having higher levels of innovative output. However, the results did not find that companies with university linkages achieve higher financial performance than similar firms without such linkages (George et al., 2002). “Procter and Gamble announced that they were able to increase their product success rate by 50 percent and the efficiency of their R&D by 60 percent by introducing the open innovation concept to the organization” (Enkel et al., 2009). Based on the information provided above following hypothesis will be analyzed based on data obtained from an innovation survey of German companies:

Hypothesis 1 (H1): The majority of companies in the investigated sample has fully adopted OI.

2.3 Innovation-supportive management and organizational culture

Though many managers acknowledge the importance of innovation, few managers are really committed to innovation-related strategies such as long term R&D investments and the adoption of cutting-edge technologies. Based on a multi-source dataset of 335 firms over nine years, empirical analysis reveals that top managers' innovativeness makes them more likely to adopt exploration orientation over exploitation orientation in innovation (Wang and Dass, 2017). However, top management teams have to sustain organizational performance by effectively explore and exploit, which is managing strategic contradictions (Smith and Tushman, 2005). Exploration and exploitation at the same time is a balancing act for many organizations and those who can manage it, are called ambidextrous organizations (O'Reilly and Tushman, 2004). Many organizational and environmental factors influence a firm's commitment to innovation. Among the organizational factors, the perceptual lens of the top management team and the team's dynamics are posited to have a significant direct impact on the firm's commitment to innovation (Daellenbach et al., 2002). Based on their study, these authors determined that results clearly indicate a positive relationship between the technical orientation of the T-MGMT and CEO and above-average R&D intensity. Based on a case study of six entrepreneurial and innovative organizations and in-depth interviews with senior managers it could be concluded that organizational culture and management style are crucial factors affecting the development of entrepreneurial and innovation behavior in organizations (Fang, 2005). Most managers know that organizational culture influences the firm's economic consequences and recognize its important role in shaping product-innovation processes. “Highly innovation-supportive cultures are credited with fostering teamwork and promoting risk-taking and creative actions that seem directly linked to effective new product development" (Jassawalla and Sashittal, 2002). There is no doubt that organizational culture is a key to managing innovation. In creating a supportive organizational environment for innovation, several practices relating to managing people have been identified in literature. While, in general, it is necessary for management to provide a quality of working life for its employees that serves their needs in terms of overall wellbeing, skills development, and career paths, there are several specific key practices aimed at building innovative behaviors; among these are empowerment and involvement. Further to this, innovation scholars suggest that extrinsic reward is necessary for encouraging innovation (Prajogo and Ahmed, 2006). Other scholars suggest that an innovation culture scale may best be represented through a structure that consists of seven factors identified as innovation propensity, organizational constituency, organizational learning, creativity and empowerment, market orientation, value orientation and implementation context. An innovation culture has been defined as a "multi-dimensional context which includes the intention to be innovative, the infrastructure to support innovation, operational level behaviors necessary to influence a market and value orientation and the environment to implement innovation". Thus, a culture supporting innovation engages behaviors that would value creativity, risk taking, freedom, teamwork, be value seeking and solution oriented, communicative, instill trust and respect, and be quick on the uptake in making decisions (Dobni, 2008). Other studies report and elaborate a more inconsistent view of innovation-supportive culture (Khazanchi et al., 2007). It was found that flexibility values foster a culture of experimentation and empowerment, whereas, control values may set boundaries that facilitate managerial trust and evaluation. Thus, innovation-supportive culture may appear paradoxical because of flexibility and control co-existing in underlying values and practices, but also may stem from conflicting views held by occupational and hierarchical sub-cultures within the organization (Khazanchi et al., 2007). Chandler et al, (2002) found in their study on determinants and consequences of an innovation-supportive organizational culture that supervisory support and reward system are both positively related to an innovative culture. Van de Ven describes one of the central problems in managing innovation, the human problem of managing attention, because people and their organizations are largely designed to focus on harvest and protect existing practices rather than pay attention to develop new ideas (Van de Ven, 1986). Furthermore the leadership style clearly influences innovation climate in organizations. A study including 372 employees and their immediate supervisor in the hotel business lead to the indication that transformational leaders can foster a climate for innovation which promotes employee creativity. Further, a significant moderating role of creative self-efficacy was found in the relationship between innovation climate and the employees' creativity. The findings reveal that employees with high creative-self-efficacy resort to creative behavior when they receive a supportive innovation climate (Jaiswal and Dhar, 2015). The question is not why to innovate, but how to innovate. In answer to this question, there are basically two ways to stimulate innovation in a company (Van Der Meer, 2007): First *culturally* by creating an innovative climate and second s*tructurally*, by a systematic use of innovation mechanisms. The cultural approach towards enabling innovation entails creating an innovative climate. Several factors important to an innovative climate are summarized in Table 1.

Table 1: Several factors important to an innovative climate (adopted from Van der Meer, 2007)

Negative		Factor		Positive
short	←	horizon	→	long
kept out	←	maverick	→	accepted
punished	←	failures	→	tolerated
formal	←	communication	→	informal
kept out	←	uncertainty	→	accepted
analyses	←	planning	→	action
means	←	planning	→	opportunities
closed	←	external cooperation	→	open
autocratic	←	decision making	→	participative
internal	←	orientation	→	customer
vague	←	strategy	→	clear

The provided information leads to the following hypothesis, which will be further investigated:

Hypothesis 2a (H2a): An innovation supportive top management, a positive innovation culture and a proper innovation process support the adoption of OI in organizations.

Hypothesis 2b (H2b): Companies which are more engaged in adopting OI have a higher innovation success rate.

2.4 Innovation management system, measuring performance and benchmarking

Innovation consists of many different elements which have to be considered for the measurement of innovation success. A synthesized framework for a discussion of innovation management measurement has been established (Adams et al., 2006). The innovation management process consisted of seven categories: inputs management, knowledge management, innovation strategy, organizational culture and structure, portfolio management, project management and commercialization (Table 2). Each category of the framework was populated with factors empirically demonstrating to be significant in the innovation process and illustrative measure to map the territory of innovation management measurement.

Table 2: Innovation management measurement areas adapted from (Adams et al., 2006)

Framework category	**Measurement areas**
Inputs management"	People, physical and financial resources tools
Knowledge management	Idea generation, knowledge repository, information flows
Innovation strategy	Strategic orientation, strategic leadership
Organization and culture	Culture, structure
Portfolio management	Risk/return balance , optimization tool use
Project management	Project efficiency tools, communications, collaboration
Commercialization	Market research, market testing, marketing and sales

Another study identified nine constructs that drive performance. "In rank order of their impact on performance, the main performance drivers are: a high-quality new product process; a clear, well-communicated new product strategy for the company; adequate resources for new products; senior management commitment to new products; an entrepreneurial climate for product innovation; senior management accountability; strategic focus and synergy (i.e., new products close to the firm's existing markets and leveraging existing technologies); high-quality development teams and cross-functional teams" (Cooper and Kleinschmidt, 1995). However, when it comes to measuring innovation performance different suggestions are made. Representatives of large corporations were asked at a conference how their organization measures its innovation performance (Mankin, 2007). Four of the many kinds of measures cited as preferred ways for companies to evaluate their innovation performance were:

1) Number of ideas funded
2) Return on investment (ROI) or project net present value (NPV)
3) Innovators in senior positions and CEO commitment
4) Long term customer adoption

Other scholars have summarized certain parameters, which have been suggested repeatedly as objective measures of economic innovation performance at the firm level: percentage of sales from innovations, percentage of profits from innovation, number of innovations, number of patents, innovation expenditure relative to sales and reduction of costs due to the implementation of process innovations (Dömötor et al., 2007).

The Balanced Scorecard (BSC) was developed as a simple measurement tool to track companies' performance (Kaplan and Norton, 1992) . The traditional view to only measure the financial indicators of a firm was complemented in the BSC to obtain the following four perspectives: 1) Financial, 2) Customer, 3) Internal Business Process, 4) Learning and Growth (Flores et al., 2009). Brau et al. (2013) suggest an open innovation scorecard as a strategic management tool to measure the success of open innovation and open innovation projects. It includes five perspectives (internal business structure, intellectual capital, collaboration, innovation and finance) which are organized hierarchically. In this open innovation scorecard the starting point is the adaption of the internal business structure to improve the absorption of external know-how. Following this goal, the second objective includes employee training- and awareness-raising for the new innovation paradigm. The next step comprises recognizing, absorbing and utilizing external knowledge (i.e., absorptive capacity). For example, collaborating with lead users can improve the absorptive capacity. Combining the first three perspectives allows the firm to develop products that are more customer-oriented, implying reduced market risks. In turn, lower risks and more customer-oriented products will have an impact on profits. This example shows that the open innovation scorecard is a flexible tool, which can be used in different settings (Brau et al., 2013). Although BSC is widely used in the business arena, the original one was not developed to assess the impact of collaborative research projects under an open innovation strategy (Flores et al., 2009).

Originally, benchmarking, which will also be applied in this study, had been described as a practice that promotes imitation (Main and Rahul, 1992). In fact, looking outside the firm boundaries and performing comparison with others in terms of both, practices and performances, enables the process of acquiring external explicit/tacit knowledge. Such acquired knowledge, once integrated with previous internal knowledge of the firm, creates new knowledge that may give rise to improvements and innovations (Massa and Testa, 2004). Benchmarking is subject to a variety of definitions: it has been defined as a continuous search for an application of significantly better practices that leads to superior competitive performance. Others note that benchmarking is the process by which organizations learn modelled on the human learning performance. In essence, all of the definitions may be paraphrased as benchmarking, which is a tool to measure and improve performance (Radnor and Robinson, 2000).

In the innovation context benchmarking has also been described to improve the new product development (NPD) process. "Managing NPD is, to a great extent, a process of separating the winners from the losers. At the company level, benchmarking is helpful for identifying the critical success factors that set the most successful firms apart from their competitors. This company- or macro-level analysis also has the potential for uncovering success factors that are not readily apparent through examination of specific projects" (Cooper and Kleinschmidt, 1995).

Based on the provided literature following hypothesis will be investigated:

Hypothesis (H3): Differences between the management systems of the Biotech firm and a sample of German companies can be identified in a benchmarking analysis. Concrete recommendation can be made to foster cross sectional learnings.

3. Method

3.1 Research Design

The study was based on data obtained from a questionnaire which was filled out by German companies from various sectors and an Austrian Biotech firm. Following the defined hypothesis the research was designed to assess the influence of innovation supportive management, the innovation climate & culture and the innovation process in organizations on the engagement in open innovation activities and the implementation of OI methods. Then the impact of implementation of OI was investigated on the innovation success of the companies (Figure 5). Furthermore a Biotech firm was benchmarked with the sample of German companies to foster cross sectorial learning and to identify Biotech industry specific innovation patterns.

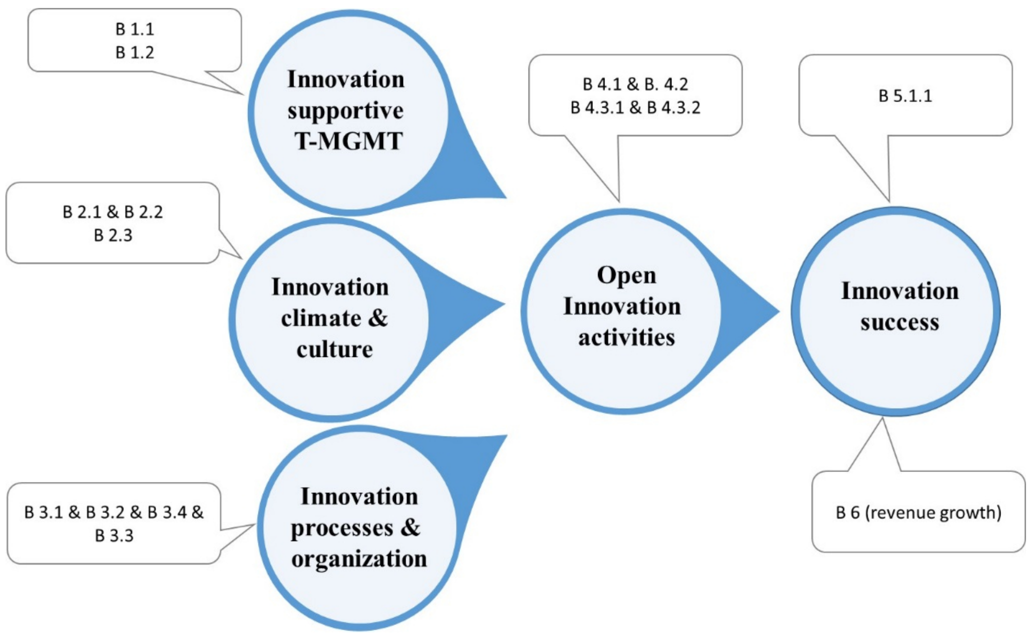

Figure 5: Design of the study based on the investigated model. Main topics ("chapters") with subjacent questions (see 3.2.2 for detailed questions)

3.2 Data collection

3.2.1 Survey method

The data for this study were gathered in the frame of a survey project at the WU Vienna, Institute for Entrepreneurship & Innovation in the time frame of May 2017 until March 2018. Univ. Prof. Dr. Nikolaus Franke, Assoc. -Prof. Dr. Peter Keinz and Michael Nobis, M.Sc., MIM (CEMS) were in charge of this project and developed the underlying questionnaire.

The research team was supported by master students of the master program “Strategy, Innovation and Management Control” from WU Vienna. The questionnaire comprised of 172 questions and was sent to 909 German companies employing between 10 and 5,000 people. Companies were randomly selected with the help of the online database Orbis[4]. The companies were categorized in 3 classes according to their employee number: 10-50, 51-200 and more than 200 employees. A link to the online survey (Qualtrics Survey Software[5]) was shared via an e-mail with companies in Germany belonging to different sectors. The e-mail with the respective link was sent to the CEO of the company together with an official introduction of the research project, an explanation of the merit for the scholars and the participating companies. Additionally contact details of the project responsible were provided. After five working days the companies got an electronic reminder and after three more working days students of the master program tried to reach the selected companies via telephone. Dependent on the interest of the selected company further phone calls were made and the contact via e-mails was maintained. Data collected from 38 German companies between June 2017 and February 2018 have been made available for the current study. For the Austrian Biotech firm the Research Director was responsible for organizing the respective information for the questionnaire. Data were obtained from the human resource-, finance- and IP- departments. Furthermore, the CEO, the innovation manager and competence centers (product management units) gave input to certain questions of the survey.

3.2.2 Questionnaire

The full questionnaire consisted of 172 questions, which were categorized into the following main topics (“chapters”): Innovation supportive top management, innovation climate and culture, innovation process and organization, open innovation activities and innovation success. Each of the main chapters consisted of a different number of subjacent questions (Figure 5). Either numerical data (e.g. number of employees, revenues, number of patents, etc.) had be provided or rational and ordinary scales were used for the rating of the respective question.

[4] https://orbis.bvdinfo.com

[5] https://www.qualtrics.com/de/

The first category (**chapter 1**) in the used model comprised questions to which extent management supports innovation in the respective organization. Following questions were asked to investigate the T-MGMT support of innovation projects:

Questions B 1.1 **Innovation supportive top management**	**entirely** **(5)**	**fairly** **(4)**	**partly** **(3)**	**somewhat** **(2)**	**not at all** **(1)**
Definition of goals	¡	¡	¡	¡	¡
Monitoring of progress	¡	¡	¡	¡	¡
Delegation to innovation teams	¡	¡	¡	¡	¡
Support and motivation of innovation teams	¡	¡	¡	¡	¡
Communication of importance of external partners	¡	¡	¡	¡	¡

The commitment of the T-MGT was investigated based on following questions:

Questions B 1.2 **Commitment of management**	**Days**
Working time for innovation	¡
Days of contacts with customers	¡
Continuing education with innovation relevance	¡

Following questions were used to determine the organization and the content of the innovation strategy of each interviewee:

Questions B 1.3.1 & 2 **Organization and content of innovation strategy**	**fix part** **(4)**	**partly** **(3)**	**somewhat** **(2)**	**not at all** **(1)**
Follow concrete Innovation Strategy (IS)	¡	¡	¡	¡
Communication of IS to employee	¡	¡	¡	¡
IS is continuously adapted	¡	¡	¡	¡
Consider new business models and markets	¡	¡	¡	¡
Consider future customer demands	¡	¡	¡	¡
Identification and care of core competencies	¡	¡	¡	¡
Involvement of external partners in innovation	¡	¡	¡	¡
Proactive management externals and strategic alliances	¡	¡	¡	¡
Prognosis and consideration of disruptive innovations	¡	¡	¡	¡

The second category (**chapter 2**) in the used model consisted of questions regarding the innovation climate and culture from two perspectives, from the company- (B 2.1 & B 2.2) and the employee view (B 2.3). Subsequent questions were asked:

Questions B 2.1 & B 2.2 **Innovation focus and initiatives of employees**	**entirely (5)**	**fairly (4)**	**partly (3)**	**somewhat (2)**	**not at all (1)**
Company culture supports entrepreneurial and innovative activities	¡	¡	¡	¡	¡
Learning from mistakes and failures	¡	¡	¡	¡	¡
Expect employees to communicate with externals	¡	¡	¡	¡	¡
Employees are initiative, engaged and feel self-responsible	¡	¡	¡	¡	¡
With good ideas employees can contact management	¡	¡	¡	¡	¡
Innovative people get promoted more quickly	¡	¡	¡	¡	¡

Questions B 2.3 **Innovation climate - employee perspective**	**%**
Working place is inspiring for innovation	¡
Improving processes is part of my job	¡
Enough time/room for innovation	¡
My superior is very interested in my suggestions	¡
If my proposal is good I can be sure it will be taken serious	¡
Lateral thinking and unconventional ideas are supported	¡
(Constructive) criticism is appreciated	¡
Innovative and entrepreneurial people can make career	¡
Failures are accepted (if innovative idea fails)	¡
That’s the most innovative firm I've ever worked for	¡

In this chapter it was also assessed if respondents have an idea management system installed. When this was applicable detailed information had to be provided.

Questions	
% of employees submitted (an) idea(s)	¡
Number of ideas in FY16	¡
Number of ideas realized	¡
Number of ideas per employee	¡
Number of employees	¡
Financial gain in EUR	¡

In **chapter 3** of the questionnaire information on the process and organization of innovation was collected. First questions regarding observation of market, technology and competition were asked:

Questions B 3.1 **Continuous observation of market, technology and competition**	**entirely (5)**	**fairly (4)**	**partly (3)**	**somewhat (2)**	**not at all (1)**
Development in the marked are systematically observed	¡	¡	¡	¡	¡
Information of market monitoring are used for strategic decisions	¡	¡	¡	¡	¡

Then questions regarding the design and configuration of the innovation process had to be answered.

Questions B 3.2a **Design and configuration of innovation process**	**entirely (5)**	**fairly (4)**	**partly (3)**	**somewhat (2)**	**not at all (1)**
Short decision making process	¡	¡	¡	¡	¡
Systematic innovation process - from idea to market	¡	¡	¡	¡	¡
Flexibility of innovation process	¡	¡	¡	¡	¡
For each phase of process goals are defined	¡	¡	¡	¡	¡
Realization of goals is evaluated after each phase	¡	¡	¡	¡	¡
Go / kill decision after each phase	¡	¡	¡	¡	¡
Interests of all processes in the company are considered	¡	¡	¡	¡	¡

Questions B 3.2b **Design and configuration of innovation process**	**entirely (5)**	**fairly (4)**	**partly (3)**	**somewhat (2)**	**not at all (1)**
Methods and instruments for collaboration with externals are available	¡	¡	¡	¡	¡
Innovation teams consists of members of different divisions	¡	¡	¡	¡	¡
Our processes optimally support incremental innovations	¡	¡	¡	¡	¡
Our processes optimally support radical innovations	¡	¡	¡	¡	¡
Good mix between incremental and radical innovations	¡	¡	¡	¡	¡
Good mix between short- and long term projects	¡	¡	¡	¡	¡
Ideas of external sources have the same chance	¡	¡	¡	¡	¡
Project management software works real time	¡	¡	¡	¡	¡

The next set of questions in chapter 3 referred to the instruments and methods which are applied:

Questions B 3.3 **Instruments and methods**	**entirely (5)**	**fairly (4)**	**partly (3)**	**somewhat (2)**	**not at all (1)**
Project management	¡	¡	¡	¡	¡
Stage Gate Process	¡	¡	¡	¡	¡
Business Modell Canvas	¡	¡	¡	¡	¡
Blue Ocean method	¡	¡	¡	¡	¡
Lean start-up method	¡	¡	¡	¡	¡
Agile process (e.g. Scrum)	¡	¡	¡	¡	¡
Design Thinking	¡	¡	¡	¡	¡
Risk and scenario analysis	¡	¡	¡	¡	¡

The last subset of questions in chapter 3 were compiled to investigate the organizational design of the organizations:

Questions B 3.4.1 & 3 **Organizational design**	**entirely (5)**	**fairly (4)**	**partly (3)**	**somewhat (2)**	**not at all (1)**
Involvement of employees in decision making	¡	¡	¡	¡	¡
People can act before superior approves it	¡	¡	¡	¡	¡
Task are exactly assigned	¡	¡	¡	¡	¡
It is always checked if employees follow tasks	¡	¡	¡	¡	¡
Every employee has follow strictly defined tasks	¡	¡	¡	¡	¡
Employees always do their job in the same way	¡	¡	¡	¡	¡
Gatekeepers are influential people	¡	¡	¡	¡	¡
Gatekeepers have a lot of experience in innovation	¡	¡	¡	¡	¡

The questions in category four (**chapter 4**) of the questionnaire were compiled to generate information on the position of marketing and sales of each organization in the innovation process (B 4.1 & B 4.2) and on short- and long term open innovation activities. Following questions were asked:

Questions B 4.1 & B 4.2 **Involvement of marketing and sales**	**entirely (5)**	**fairly (4)**	**partly (3)**	**somewhat (2)**	**not at all (1)**
Our marketing / sales initiates innovation projects (IP)	¡	¡	¡	¡	¡
Marketing brings in customer perspective in IP	¡	¡	¡	¡	¡
Marketing / sales has veto and can stop IP	¡	¡	¡	¡	¡
Marketing and sales is integrated in all phases of IP	¡	¡	¡	¡	¡
Feedback of (potential) customers is asked very early	¡	¡	¡	¡	¡
Market launch of innovations is already planned during development	¡	¡	¡	¡	¡

A subset of questions were compiled to generate information of the engagement of the respondents on short term innovation activities (B 4.3.1).

Questions B 4.3.1 **Short term initiative in Open Innovation (OI)**	**> 500,000**	**500,000 - 250,001**	**250,000 - 100,001**	**100,000 - 50,001**	**50,000 - 25,001**	**25,000 - 1**	**none**
Cooperation with innovation agencies and intermediaries	¡	¡	¡	¡	¡	¡	¡
Involvement of focus groups	¡	¡	¡	¡	¡	¡	¡
Active scouting	¡	¡	¡	¡	¡	¡	¡
Establishing and using of own user communities	¡	¡	¡	¡	¡	¡	¡
Utilization of lead user method	¡	¡	¡	¡	¡	¡	¡
Crowd sourcing and ideas competition	¡	¡	¡	¡	¡	¡	¡
Implementation of toolkits for user innovation	¡	¡	¡	¡	¡	¡	¡
Participation / organization of Hackathons	¡	¡	¡	¡	¡	¡	¡

In this case currency intervals were used and the respondents had to mark the interval in which their investment (in EUR) for the respective initiative had fallen in the last year. For correlation and regression analysis and displaying the information in radar charts the currency intervals were transferred in numbers from 7 (> 500,000 EUR) to 1 (none).

Next to information regarding short term open innovation activities data on long term OI activities were collected. Again, the approximate amount of EUR invested in the respective initiative had to be provided in defined currency intervals.

Questions B 4.3.2 **Long term OI activities with external partners**	**> 500,000**	**500,000 - 250,001**	**250,000 - 100,001**	**100,000 - 50,001**	**50,000 - 25,001**	**25,000 – 1**	**none**
Formal innovation project with customer	¡	¡	¡	¡	¡	¡	¡
Formal innovation project with competitor	¡	¡	¡	¡	¡	¡	¡
Formal innovation project with supplier	¡	¡	¡	¡	¡	¡	¡
Research project with Universities and research organization	¡	¡	¡	¡	¡	¡	¡
Cooperation with start ups	¡	¡	¡	¡	¡	¡	¡

In the next set of questions information regarding labor turnover and training of employees had to be provided:

Questions B 2.3 and 2.4.1 – 4 **Support of employee innovation potential**	**% / days**
Labor turnover in %	¡
Training / education in days	¡
Education in field of OI	¡
Information of employees on OI	¡

As series of questions was compiled to assess how employees are motivated to support innovation, in particular OI activities.

Questions B 2.4.3 & 4 & 5 **Motivation of employee innovation potential**	**Yes**	**No**
Regulation for free time for innovation ("Google")	¡	¡
Internal venture capital	¡	¡
Employee profit sharing plan	¡	¡
Formal idea management system	¡	¡
Specific incentive for ideas outside of firm	¡	¡
Specific incentive for collaborating with external partners	¡	¡

In the category of innovation success (**chapter 5**) the percentage of revenues with newly developed or improved products or products already existing for a longer time had to be provided:

Questions B 5.1.1 & 5.1.2 **Innovation success**	**%**
Category 4: Revenues with products / services new to the market during last 3 years	¡
Category 3: Revenue with products / services improved during last 3 years	¡
Category 2: Revenues with new or improved products, which competitors already have	¡
Category 1: Revenues with products / services not changed during last 3 years	¡
Revenues with products developed with external partners	¡
Profit with products developed with external partners	¡

Other information which had to be provided were revenues and staff members in the year 2012 to 2016 and also numbers of granted national and international patents.

3.3 Data analysis

The data provided via linear or ordinal scales had to be converted into numerical information for statistical analysis. The statements "*entirely – fairly – partly - somewhat* or *not at all*" were converted into following numbers: 5=*entirely*, 4= *fairly*, 3= *partly*, 2= *somewhat* and 1 = *not at all*. In one category it was also asked if certain methods or components are part of the innovation strategy (IS) whereby following selection could be made: *fix part*, *partly*, *somewhat* and *not at all*. Similar to the procedure before these answers were again transformed into numbers: 4 = *fix part*, 3 = *partly*, 2 = *somewhat* and 1 = *not at all*. In one chapter investments in different OI- methods and activities in the last 12 month had to be specified based on currency intervals: >EUR 500,000; EUR 250,001 – 500,000; EUR 100,001 – 250,000; EUR 50,001 – 100,000; EUR 25,001 – 50,000; EUR 1 – 25,000 and none. For statistical analysis this currency intervals were converted into number (7 = >EUR 500,000 down to 1 = none).

Potential success factors for innovation such as innovation supportive top management (chapter 1), the innovation climate (chapter 2) and the innovation process and organization (chapter 3) were correlated with short- and long term open innovation activities.

For the innovation supportive management the mean values for the six answers (B 1.1) for each of the organizations was taken und correlated with the mean value of all short- and long term activities (B 4.3.1 and B 4.3.2). The innovation climate was investigated from two perspectives – the firms' (B 2.1 & B 2.2) and the employees' (B 2.3). Again questions were averaged for each company and used for the correlation analysis. The criterion formal innovation process was split up into two sections. The first section comprised the sub-questions market monitoring (B 3.1), the questions regarding design and configuration of the innovation process (B 3.2) and questions regarding the organizational design (B 3.4.1 & 3). The second section comprised questions regarding instruments and methods in the innovation process (B 3.3). As already stated above, the mean value for all questions of a respondent was taken and used for the correlation analysis. In another analysis the innovation success was correlated with the implementation and use of OI methods. For the innovation success the percentage of revenues with improved or new products in the last three years was taken (B 5.1.1.). The latter one was measured by the percentage of revenues made with new or improved products or services developed during the past three years and the revenue growth in the five-year period of 2012 to 2016. For all correlation analyses the Person's (PR) and the Spearman's correlation (SR) coefficients were used to describe the linear co-movement between two variables. "-1" indicates a strong negative correlation, "0" means that there is no association between the two variables and "1" indicates a strong positive correlation. The original idea of correlation was conceived by Francis Galton and formally developed by Karl Pearson (Stigler, 1989). Although the correlation coefficient does not measure the causal relationship between two variables, it plays an important role in many scientific areas (Kim et al., 2015). Since the number of respondents was quite low in this survey and the firms differed in size, extreme values (outliers) were not removed. Therefore it was decided not only to calculate PR but also the Spearman's correlation (SR), because the latter one is less affected by outliers as it is a non-parametric test (distribution-free). The Pearson & Spearman correlations between pairs of question topics were analyzed with the core function in the stats package using R software version 3.4.3 (R Core Team, 2017[6]).

Additionally, robust linear regression was used to investigate any combined effect of innovation supportive T-MGMT, the innovation climate & culture as well as innovation process & organization on the engagement of OI activities (Figure 6). The robust fitting of linear models (rlm) function of the Mass package of R was used. Means of B 1.1, B 2.1 & B 2.2, B 3.1, B 3.2 and B 3.4 were defined as independent variable and compared to B 4.3 as dependent variable (Block 1 with Block 2). Similar to the correlation analysis above the influence of engagement in open innovation activities on innovation success was analyzed. For this the means of questions B 4.3.1 and B 4.3.2 were compared to the B 5.1 and revenue growth (Block 2 with Block 3).

[6] https://www.r-project.org/

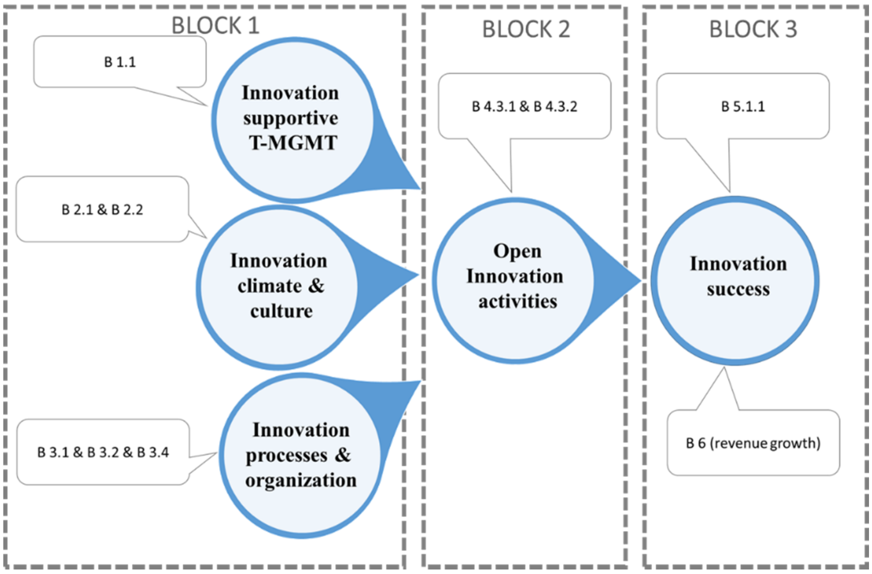

Figure 6: Employed model for regression analysis

Furthermore, an Austrian Biotech company was benchmarked with the peer group regarding the 5 main chapters of this survey but with a main focus on open innovation performance. The descriptive statistics of the question items were analyzed with the mean, min and max functions in the base package and with the median functions of the stats package using R software version 3.4.3 (R Core Team, 2017[7]). The mean values of the peer group were compared with respective values of the Biotech firm and displayed in radar charts.

The benchmarking method was used for this parts of the thesis, as this method is clearly related to the idea of finding inspiration from outside the organization. It is the process of learning from others and involves comparing one's own performance or methods against other comparable organizations (Slack, 2016). Different forms of benchmarking have been described such as internal and external benchmarking, competitive and non-competitive benchmarking, performance benchmarking and practice benchmarking.

[7] https://www.r-project.org/

4. Results

The main focus of this study was on OI activities and methods. First the group of German companies was analyzed regarding their OI adoption rate. Next the effect of innovation supportive management, innovation climate and informal innovation process on the implementation of OI methods and activities was evaluated. Further it was investigated if the adoption of OI methods have a positive effect on innovation performance (revenue growth or percentage of revenue with new or improved products). Finally the IMP of an Austrian Biotech firm was benchmarked with the sample of German companies (peer group).

4.1 Characterization of the peer group with focus on open innovation

75 percent of the German companies investigated in this study were family owned. They had an average turnover of 151 million Euro (Table 3). The average number of employees was 949 and the average innovation expenses added up to EUR 1.76 million. The German peer group had an average revenue growth rate of 28 percent and expected a growth of the number of employees of 7.51 percent in the next two years. The firms belonged to the following industrial sectors: Manufacturing and machinery, engineering, IT and security, electronics and software development, construction and building materials and paper.

Table 3: Characterization of German companies compared to Austrian Biotech firm

Criteria	**German companies (peer) group**		**Biotech company**
	Mean	***range***	
Turnover (Mio EUR) in 2016*	151	€ 1,0 - 2,300	189
Employees in 2016	949	45 - 11,300	720
Innovation expenses in 2016 (Mio EUR)	1.76	0.025 - 20	10.7
Innovation rate in 2016 (%)	3.51	0.1 – 35	5.7
Revenue growth from 2012-2016**	28%	-18% - 127%	78%
Staff growth rate next 2 years (%) ***	7.51%	1 – 29%	18%

** 20 out of 38 provided information; ** 27 out of 38 provided information; *** 24 out of 38 answered*

The Biotech firm which was benchmarked against the German group of companies had a turnover of EUR 189 million, 720 employees, EUR 10.7 Mio innovation expenses, an innovation rate of 5.7 percent, a revenue growth of 78 percent between 2012 and 2016 and an expected staff growth of 18 percent for the next two years.

Table 4 shows that 31 companies provided information regarding their OI expenses and the application of short- and long term OI methods. In Table 12 (Appendix) details regarding the application of short- and long term methods and activities for each of the organizations are displayed. Each of the companies that provided detailed information concerning OI activities was engaged in OI at least to a certain extent. Out of the 31 organizations, three did not use any of the short term OI initiatives and two did not engage with any of the long term OI activities (Appendix, B 4.3.1a, B 4.3.2a; Table 12). In average, the examined companies (31) used five of the OI methods and activities and spent EUR 190,726 on them. The average OI expenses for 28 companies (three companies did not provide their staff number) was EUR 861 per employee. The global staff number from each company was taken from the questionnaire. It seems that four companies (9, 20, 28 and 32) have not correctly assessed their innovation expenses as the OI expenses are higher. However, it has to be mentioned that the OI expenses are maximum values as not exact numbers but rather ranges were asked in the questionnaire.

Table 4: Overview of the German companies (1 to 38) and of the Austrian Biotech firm Innovation expenses, number of employees and revenues in EUR are displayed. Additionally, expenses of OI activities were summarized, OI expenses per employee and number of different OI activities and methods used were calculated

Companies	Innovation expenses	N° staff	Revenue EUR	Expenses OI total	OI expenses per head	N° of OI
1	200,000	90	13,000,000	87,500	972	2
2	350,000	65	6,000,000	275,000	4,423	5
3	90,000	150	21,500,000	75,000	500	1
4	120,000	115	8,600,000	62,500	543	5
5	1,200,000	50	5,200,000	125,000	2,750	5
6	700,000	172	30,000,000	300,000	1,744	7
7	50,000	330	47,000,000	112,500	341	7
8	500,000	na	na	0	na	na
9	25,000	na	na	75,000	na	6
10	150,000	na	na	0	na	na
11	35,000	na	na	0	na	na
12	120,000	na	na	25,000	na	2
13	500,000	na	na	0	na	na
14	1,000,000	na	na	0	na	na
15	80,000	na	na	0	na	na
16	500,000	45	50,000,000	187,500	20,833	4
17	1,000,000	172	51,000,000	50,000	291	4
18	30,000	89	9,400,000	37,500	421	3
19	1,000,000	132	41,000,000	450,000	3,409	3
20	250,000	460	103,000,000	462,500	2,636	3
21	200,000	400	63,000,000	62,500	156	5

22	60,000	311	34,130,000	100,000	322	6
23	300,000	230	50,000,000	212,500	978	10
24	5,000,000	3,409	446,000,000	225,000	66	7
25	5,000,000	1,650	145,000,000	237,500	152	9
26		504	69,000,000	87,500	198	7
27	500,000	950	80,000,000	125,000	132	5
28	150,000	1,698	189,200,000	300,000	221	10
29	15,000,000	615	130,000,000	462,500	772	6
30	400,000	760	120,000,000	50,000	66	4
31	3,000,000	11,300	2,300,000,000	1,050,000	93	6
32	150,000	700	14,000,000	200,000	286	5
33	350,000	450	1,000,000	25,000	56	2
34	1,000,000	na	0	175,000	na	7
35	5,000,000	na	0	0	na	na
36	1,000,000	470	120,000,000	100,000	213	6
37	250,000	853	25,000,000	12,500	103	1
38	200,000	400	80,000,000	162,500	406	6
Biotech	10,700,000	846	189,360,000	1,100,000	1,345	6

Regarding their OI adoption potential, the examined companies were categorized based on their spending in OI and the number of different methods used or activities involved. More exactly, the OI expenses per employee and year and the number of different OI methods and activities were used to categorize them into “high”, “medium” and “poor” adopters (Table 5).

Only 7.1 percent of the companies spent more than 2,500 Euros on OI activities and used five or more different methods or initiatives (high adopters). 21.4 percent can be categorized as medium adopters (expenses of more than 400 Euros per staff and year, and more than four methods or initiatives used) and the majority (71.4 percent) can be allocated to the category of the poor adopters (OI spending < EUR 400 per staff and year and less than four methods or activities employed).

Table 5: Categorization of OI adoption. Based on yearly OI expenses per staff member and number of different OI methods used and initiative engaged

	OI expenses per employee and year	N° of different OI methods and activities used	% of firms in each category
High adopters	> EUR 2,500	> 5	7.1
Medium adopters	> EUR 400	> 4	21.4
Poor adopters	< EUR 400	< 4	71.4

Hypothesis 1 (The majority of companies in the investigated sample has fully adopted OI) has to be rejected as only 28.5 percent of companies in the peer group are medium or high adopters.

4.2 Investigation of possible influencing factors on open innovation and subsequently on innovation success

This analysis was done to answer **RQ1**: Are open innovation activities in the peer group facilitated by an innovation supportive management, the innovation climate or the existence of a formal innovation system and does the implementation of OI correlate with innovation success criteria? One of the main areas of this thesis is open innovation, the new paradigm in innovation. It basically says that companies can innovate much more quickly by looking outside their own boundaries for new technologies. In this study we therefore analyzed possible correlations between the involvement of top management in innovation projects ("innovation supportive top management") and the innovation climate (two perspectives) with open innovation activities.

Another hypothesis was that firms stronger involved in OI activities are generating more of their revenues with newer products. Therefore, the OI activities were correlated with innovation. For the innovation supportive management again the mean values of six questions (Appendix, B 1.1) for each of the organizations was taken und correlated with the mean value of all short- and long term activities (Appendix, B 4.3.1 and B 4.3.2; 15 questions). The innovation climate was used again from two perspectives – the firms' and the employees'. For the innovation success the percentage of revenues with improved or new products in the last three years was taken (Figure 7).

Moreover, the analysis revealed that in our sample of German companies there is no significant correlation between the involvement of top management in innovation projects and short- and long term innovation activities (PR = 0.01, P = 0.95; SR = 0.10). However, a significant positive correlation could be seen between engaging in OI activities and innovation success (PR = 0.47, P = 0.01; SR = 0.43).

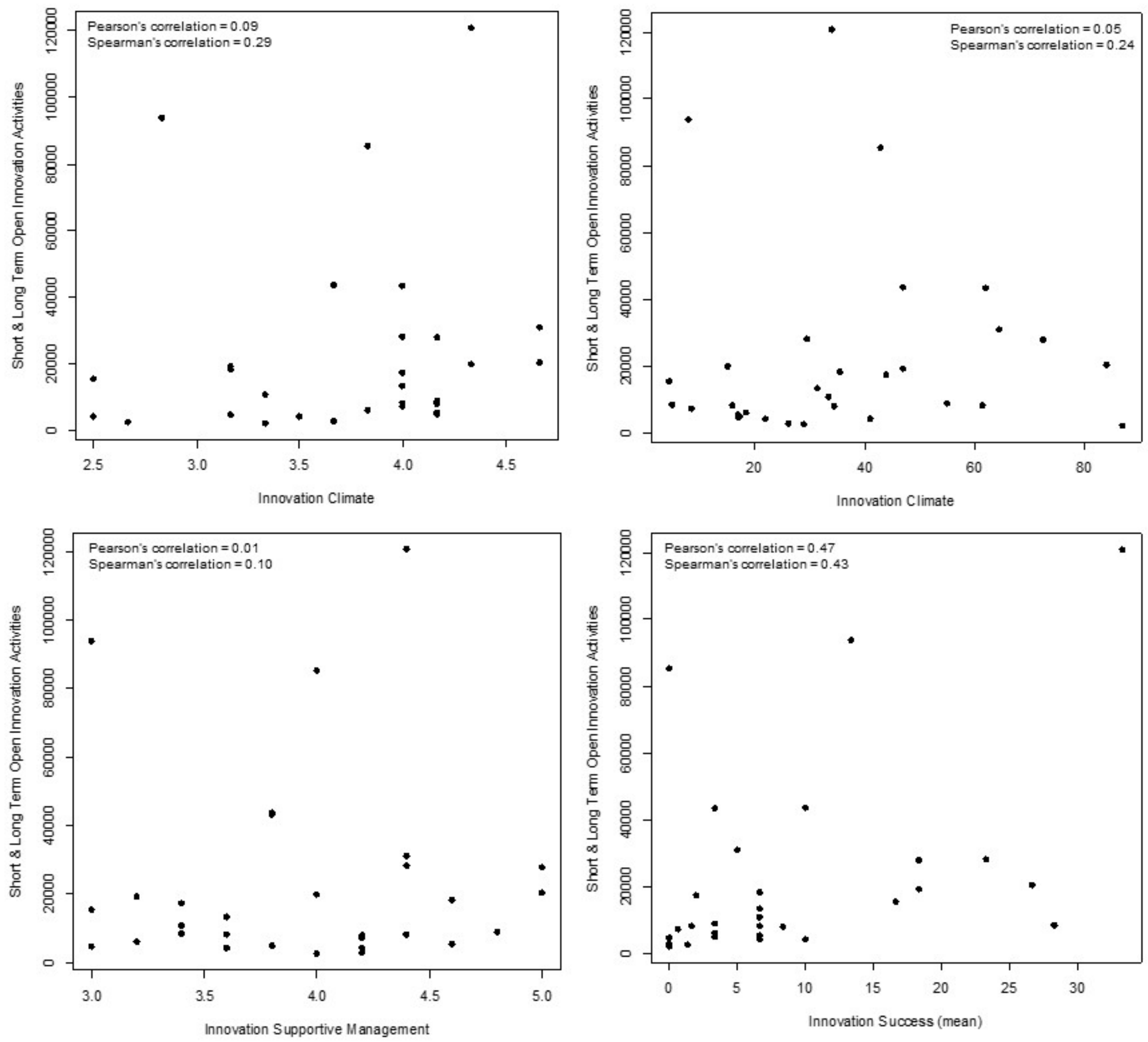

Figure 7: Correlations between OI activities, innovation climate, management and success Innovation climate from the firms' perspective (upper left diagram) and the employees' perspective (upper right) correlated with short and long term innovation activities. The correlation of the involvement of management in innovation (innovation supportive management) and open innovation activities is depicted in the lower left diagram and the influence of OI activities of the firms on the innovation success (percentage of new and improved products) is shown in the lower right diagram.

The data in this study were also used to investigate any correlation between the existence of a formal innovation management system and open innovation activities. The hypothesis for this analysis was that a formal innovation management system could either support or hinder open innovation activities. The mean for each company regarding OI activities was calculated as explained above. The criterion "formal innovation process" was split up into two sections. The first section comprises the sub-questions market monitoring (Appendix, B 3.1), the questions regarding design and configuration of the innovation process (Appendix, B 3.2a and 3.2b) and questions regarding the organizational design (Appendix, B 3.4.1 & 3).

The second section comprises questions regarding instruments and methods in the innovation process (Appendix, B 3.3). For each of the two sections of the formal innovation management process, the mean value across all the sub-questions for each company was used for correlation analysis. The analysis revealed that there is a no correlation (R = 0.09, P = 0.61; SR = 0.33) between short and long term innovation activities and the formal innovation system with regard to market monitoring, configuration of innovation system and organizational design (Figure 8 – left diagram).

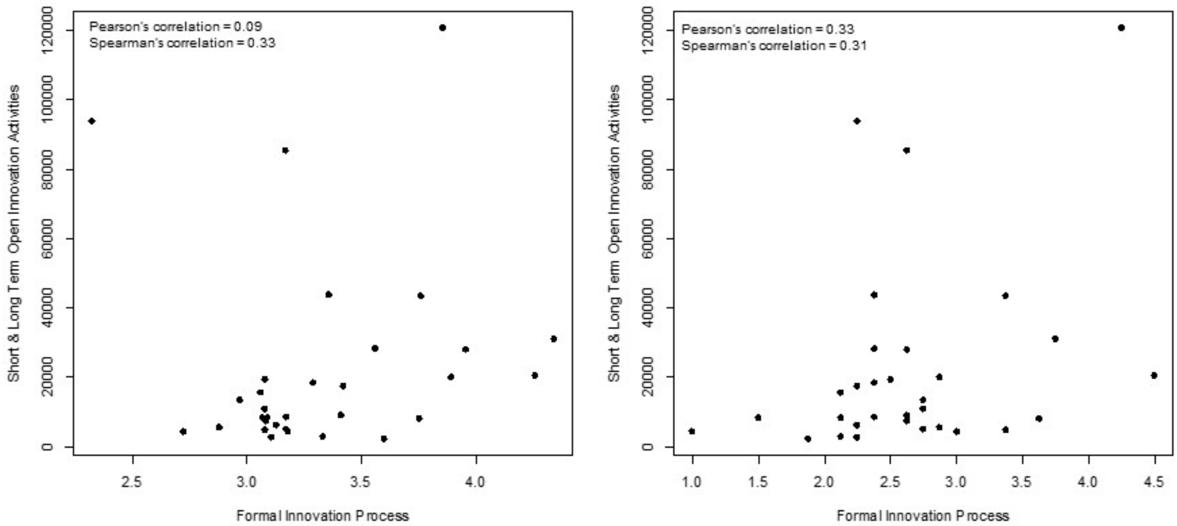

Figure 8: Correlations between the formal innovation management process and OI activities Scatterplot left: OI (market monitoring, organization and design correlated with IMP; scatterplot right: OI (instruments and methods) correlated with formal innovation process

However, when questions regarding instruments and methods were correlated with short and long term innovation activities, a positive trend (R = 0.33, P = 0.07; SR = 0.31) was observed. It seems that the use of instruments and methods in the IMP in this particular sample of German companies (R = 0.33) correlates with OI activities, however, this correlation is only statistically significant at a significance level of 10 percent (P = 0.07).

A robust linear regression was performed to analyze any combined effect of innovation supportive top management, innovation climate and innovation process and organization on the adoption of OI. Like in the correlation analysis, no significant effect of these factors could be observed on implementing and using OI (Table 6). However, the significant effect of engagement in OI activities and innovation success (percentage of turnover with new products) could be confirmed.

Table 6: Results of robust linear regression

Block	Questions		Analysis	p-value
1	B 1.1		Block 1 / Block 2	0.6282
	B 2.1 & 2.2			0.8058
	B 2.3			0.8889
	B 3.1 & 2 & 3			0.2613
	B 3.3			0.4136
2	B 4.3.1 & 2			
3	B 5.1.1		Block 2 / Block 3 (B 5.1.1)	0.0006*
	B 6		Block 2 / Block 3 (B 6)	0.8857

**significant*

According to these data it seems that companies involved in open innovation activities generate more of their revenues with new or improved products.

Based on the results of the correlation and regression analysis, **hypothesis 2a** (*an innovation supportive top management, a positive innovation culture and a proper innovation process support the adoption of OI in organizations*) has to be rejected, as the individual factors alone (correlation analysis) and in combination (regression analysis) did not have a statistically significant effect on implementation of OI. However, the formal innovation system has a positive correlation with engaging in OI activities. **Hypothesis 2b** (*companies which are more engaged in adopting OI have a higher innovation success rate*) can be accepted as there is a statistically significant effect of using OI and innovation success based on percentage of revenues with new or improved products.

4.3 Benchmarking study to identify gaps and to foster cross sectional learning

This benchmarking analysis was conducted to answer **RQ2**: What are the major differences between the innovation management processes of an Austrian Biotech firm and a sample of German companies? To which extent is OI implemented in the Biotech firm? Which concrete recommendations can be derived from the benchmarking study in order to improve the innovation management process of the Biotech firm?

Following the results of the comparison of the Biotech firm with the mean values of the peer group regarding the questions of the five main chapters of the questionnaire with its sub-chapters (“categories”) are presented.

4.3.1 Innovation supportive top management

In this chapter questions concerning involvement and commitment of top management in the innovation process, innovation strategy and innovation expenses had to be answered (Appendix B 1.1).

Figure 9 reveals, that the mean value of the 5 criteria was around 4 (fairly) for the German peer group. The Biotech firm was below the means of the peer group for "communication of the importance of external partners" (2) and for "support and motivation of innovation teams" (3). However, for the question of "delegation to innovation teams" the Biotech-firm was ranked with 5 (entirely) in this survey. "Definition of goals" and "monitoring of progress" was around 4 for both, the peer group and the Biotech firm.

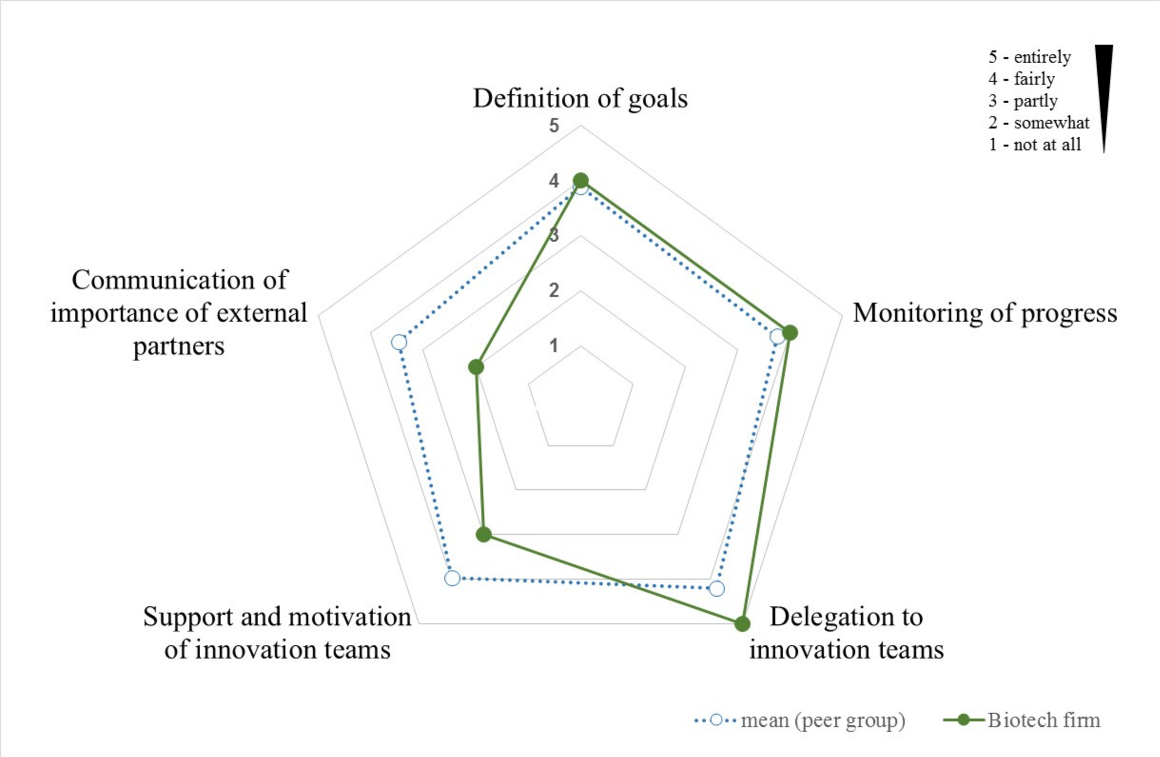

Figure 9: Contribution of top management to the innovation process

Figure 10 reveals that concerning the innovation strategy the Biotech firm is ranked significantly better for the criteria "prognosis and consideration of disruptive innovations" (4 versus 2.16) and "identification and care of core competencies" (4 versus 3.13). For all other criteria except for one, the Biotech firm is slightly above the ranking of the German peer group. Only for the criterion "communication of innovation strategy to employees" the mean value of the peer group is slightly above (2.39 versus 2). 36 companies of the peer group revealed their innovation related expenses in 2016, which averaged at 1.25 Mio Euro and was significantly lower than that of the Biotech firm with 10.7 Mio Euro (Table 3).

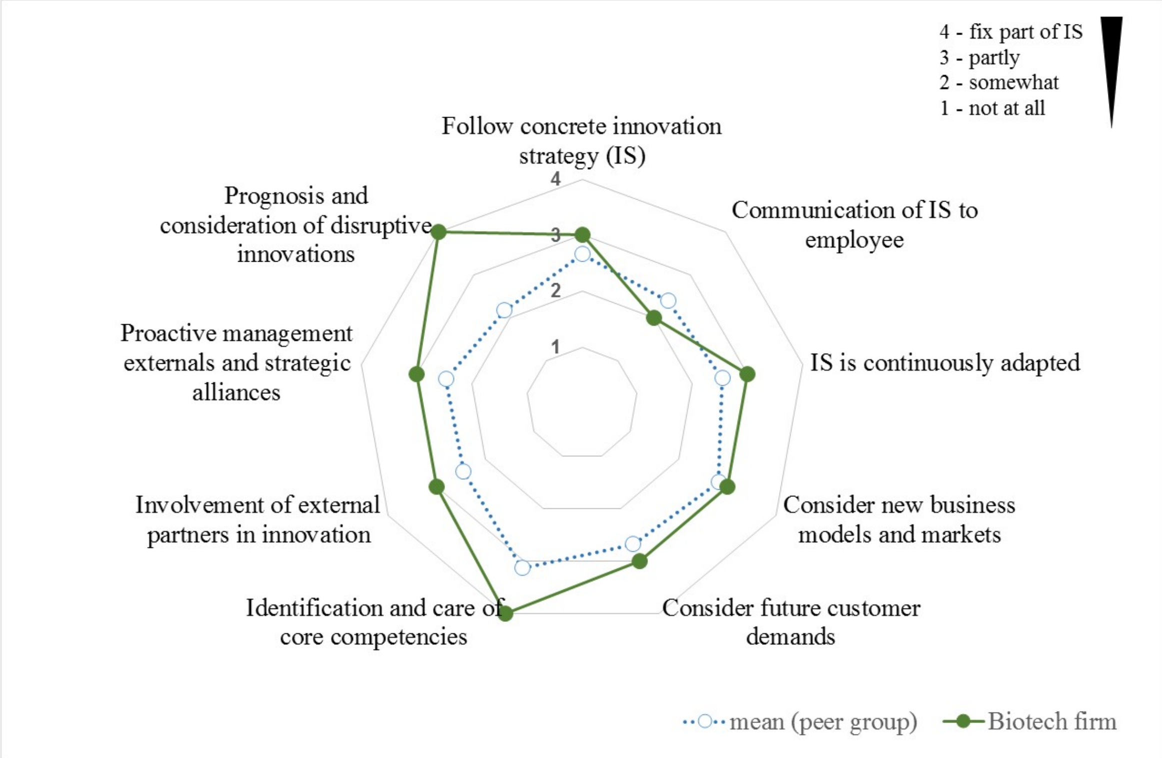

Figure 10: Organization and content of the innovation strategy

4.3.2 Innovation climate

In this category questions regarding innovation climate and innovation culture had to be answered. The aim was to find out to which extent employees are involved in the innovation process.

The Biotech firm was ranked high (5=entirely) for the criteria “with good ideas employees can contact management” and “management expects employees to communicate with externals” (Figure 11). Especially for the latter one, there is a huge gap to the peer group, which only ranks this criterion with 3.16.

It seems that “learning from mistakes and failures” is underdeveloped in the Biotech firm (2 = *somewhat*) compared to the peer group (average = 3.71) and that in the Biotech firm innovative people get not promoted more quickly (3) compared to the German peer group (3.66). The peer group and the benchmarking firm has received a high rating for engagement, initiative and self-responsibility of employees as well as that the companies support entrepreneurial and innovative activities.

Figure 11: Innovation orientation and initiative employees

As a part of this survey the innovation climate was also evaluated from the perspective of employees. Here, the consent of the employees were asked, more exactly, how many percent of the employees agree to the defined statements. Interestingly, the peer group had quite low average ratings for all the criteria with a consent rate between 28 % and 50 % (Figure 12).

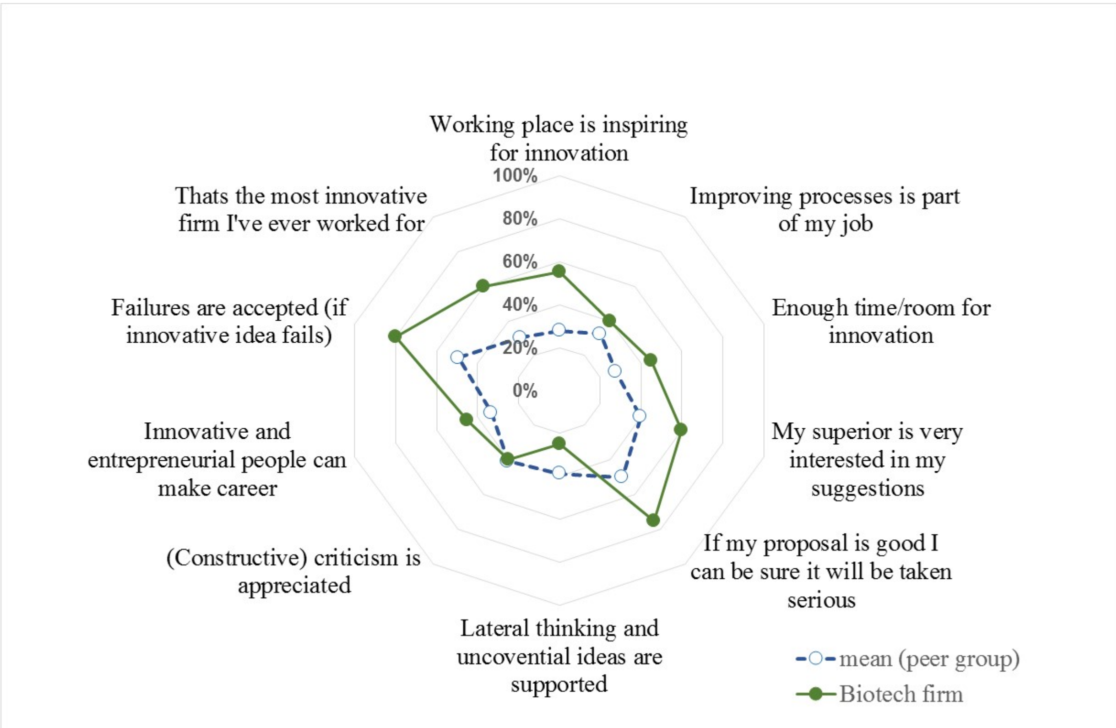

Figure 12: Innovation climate from employee perspective

Only for the statement “lateral thinking and unconventional ideas are supported” the Biotech firm was below the mean of the peer group (peer group 39%, Biotech firm 25%). Both, the peer group and the Biotech firm hat the same evaluation (~40%) for the statement “constructive criticism is appreciated”.

Following statements were ranked higher for employees in the Biotech firm compared to the peer group:

- That’s the most innovative firm I’ve ever worked for (60% versus 30%)
- Working place is inspiring for innovation (55% versus 28%)
- Improving processes is part of my job (40% versus 33%)
- There is enough time and room for innovation (45% versus 28%)
- My superior is very interested in my suggestions (60% versus 40%)
- If my proposal is good, it will be taken seriously (75% versus 50%)
- Innovative and entrepreneurial people can make career (45% versus 33%)
- Failures are accepted, if innovative idea fails (80% versus 49%)

One section of the questionnaire gathered information about the framework and environment in the organization to stimulate and support innovative behavior of the employees (Figure 13).

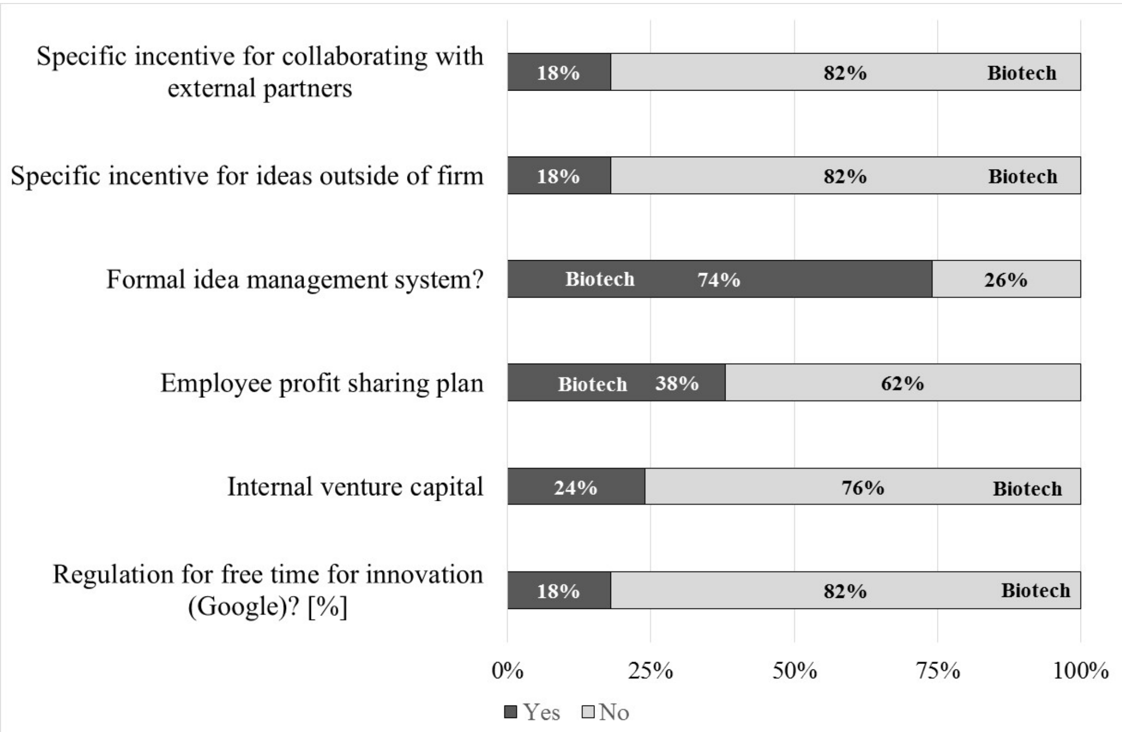

Figure 13: Environment in the organization to stimulate and support innovative behavior (Percentages of “yes” and “no” of peer group and allocation of Biotech firm according to its rating)

Interestingly only 18 percent of the firms have specific incentives for collaborating with external partners and for supporting ideas coming from outside of the organization (Figure 13). Also the Biotech firm doesn't provide incentives for ideas coming from outside.

Only 38 percent of the companies (including the Biotech firm) offer an employee profit sharing plan. Internal venture capital and free time for innovation ("Google rule") is only offered by the minority (24% and 18%). 74% of the companies, including the Biotech firm have a formal idea management system in place. In the peer group 9 percent of people submitted an idea in the year 2016 compared to 19 percent in the Biotech firm (Table 7).

Table 7: Details regarding idea management system in peer group compared to Biotech firm

	Peer group (mean)	**Biotech firm**
% of employees submitted (an) idea(s)	9	19
Number of ideas in 2016	46	218
Number of ideas realized	15	87
% of ideas realized	32.6	39.9
Number of ideas per employee	0.05	0.35
Number of employees	949	615
Financial gain for implemented idea in EUR	33,161	No answer

The average number of idea submitted was only 0.05 in the peer group versus 0.35 in the Biotech firm. The idea realization rate was similar with around 33% for the German organizations compared to around 40% for the Biotech firm. 28 companies provided information on the financial gain by implementing ideas, which in average is 33,161 Euro. The Biotech firm did not provide information as this was obviously not tracked in 2016.

4.3.3 Innovation processes and organization

This chapter aims to generate information on the conceptualization of the innovation process from the idea to the market. Furthermore methods of idea generation are evaluated and also how innovation is managed and controlled. It seems that the innovation process of the Biotech firm is more elaborated compared to the peer group (Figure 14). The German companies were ranked between 3 and 4 for the criteria asked in this section of the questionnaire. The Austrian Biotech firm was well above the peer group for all the criteria. Especially the questions "interests of all processes in the company are considered", "systematic innovation process – from idea to the market" and "for each phase of the process goals are defined" was assessed with "entirely" (5).

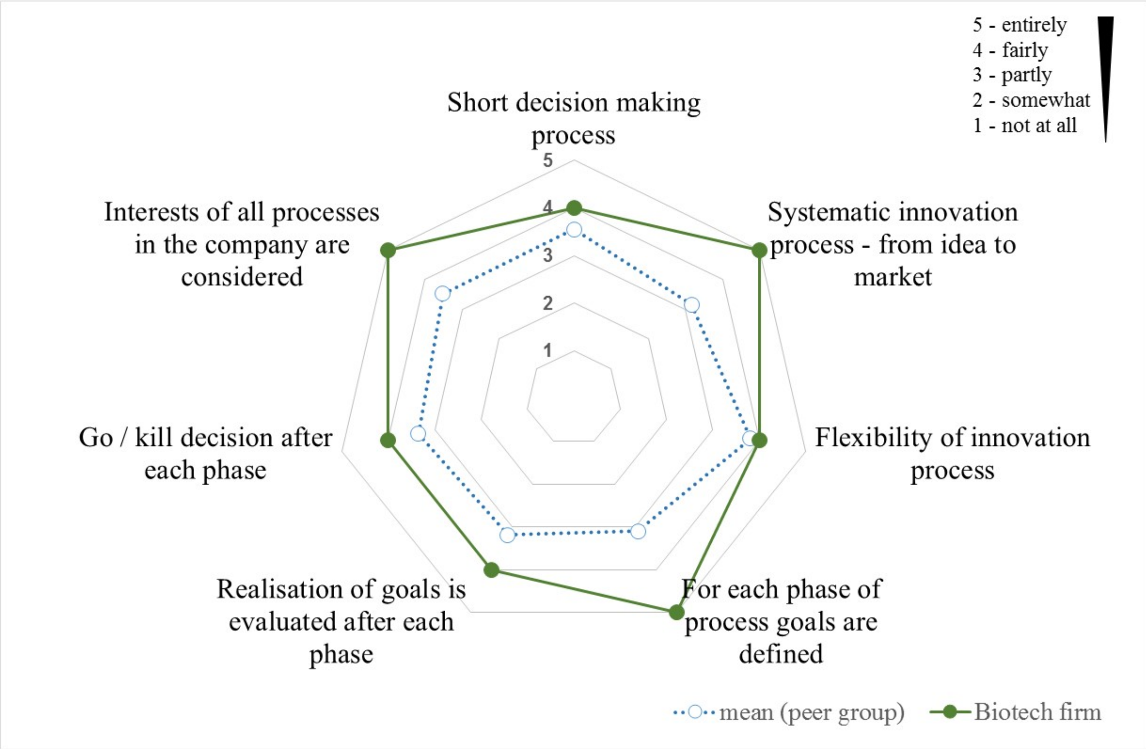

Figure 14: Conceptualization and design of innovation process

The statements "short decision making process", "go / kill decisions after each phase" and "realization of goals are evaluated after each phase" were ranked with 4 and are therefore slightly above the peer group. For the "flexibility of the innovation process" the difference is marginal with the mean of 3.81 for the peer group compared to 4 for the Biotech firm. Similarly to the before mentioned parameter on the innovation process, the Biotech firm was ranked higher for almost all criteria, except for "our process optimally supports radical innovations", which was evaluated "somewhat" (2) compared to 2.48 for the peer group (Figure 15).

The statements "our process optimally supports incremental innovations", "methods and instruments for collaboration with externals exist", "ideas of external sources have the same chance" and "a good mix between short- and long term projects" were ranked 4 for the Biotech firm which was slightly higher compared to the German companies. The statements "good mix between incremental and radical innovations" and "innovation teams comprise members of different divisions" were similarly ranked (around 4).

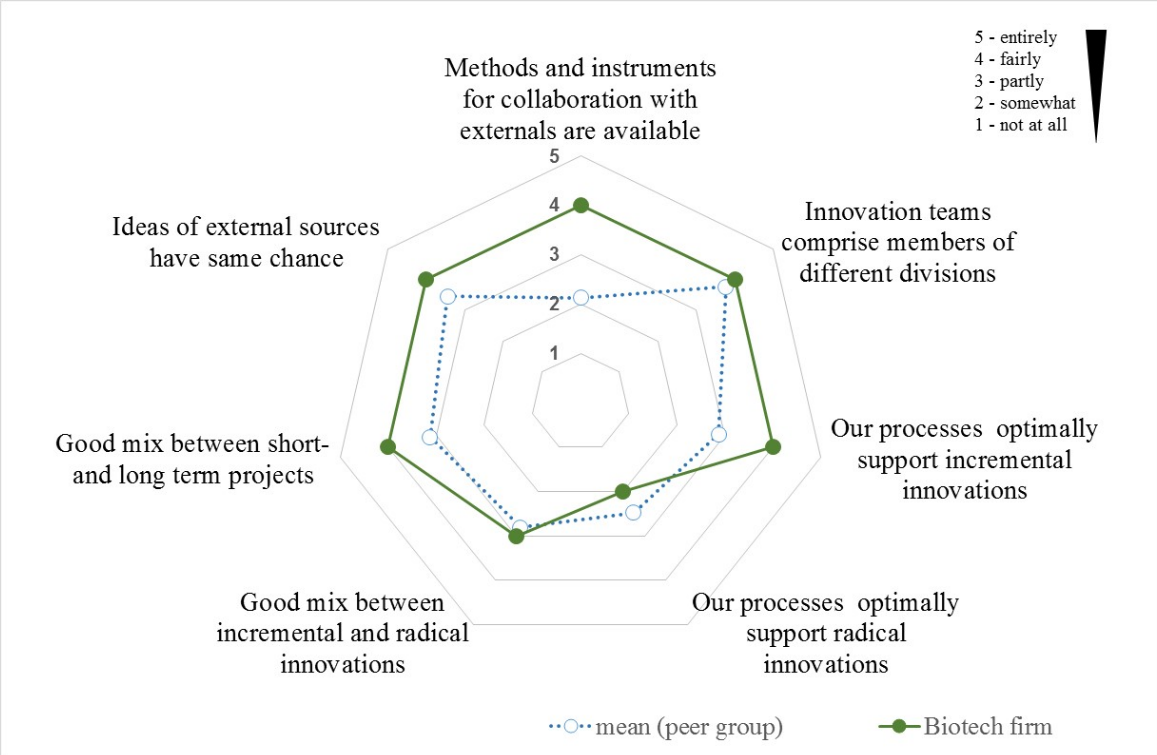

Figure 15: Conceptualization and design of innovation management system

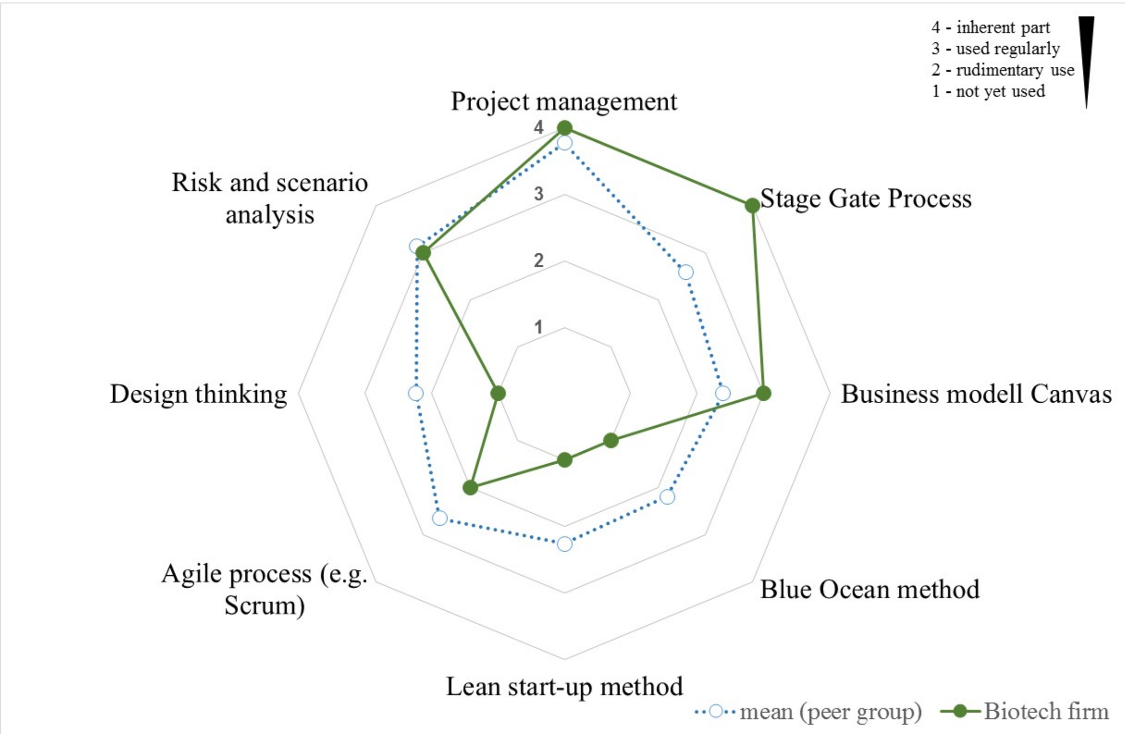

Figure 16: Instruments and methods for organization of innovation

Concerning instruments and methods for organizing innovation only four possible answer were provided. The instrument / method is an inherent part of the process (4), feature is used regularly (3), is used in rudimentary (2) and is not yet used (1). Project management is inherent part for most of the peer group members and also the benchmarked firm (Figure 16).

Stage gate process and business model Canvas is intensively used by the Biotech firm (4 and 3) but to a much lower extent by the peer group (2.58 and 2.39). No difference can be seen for the method "risk and scenario analysis", which was ranked around 3. Design thinking (2.23), agile process (2.65), lean start up methods (2.26) and blue ocean method (2.19) are only used rudimentarily in the peer group or not at all in the Biotech firm.

Concerning expectations and behavior of the organization towards employees, it can be seen (Figure 17) that the Biotech firm is only ranked higher for the two gatekeeper requirements: "Gatekeepers have a lot of experience in innovation" (4) and "gatekeepers are influential people" (5). For the criteria "involvement of employees in decision making", "people can act before superior approves", "it is always checked if employees follow tasks" and "every employee has to follow strictly defined tasks" the evaluation of peer group and the benchmarking firm have been evaluated with 3 ("partly"). The Biotech firm is below its peer group for the statements "tasks are exactly assigned" and "employees always do their job in the same way" which received an evaluation of 2 ("somewhat").

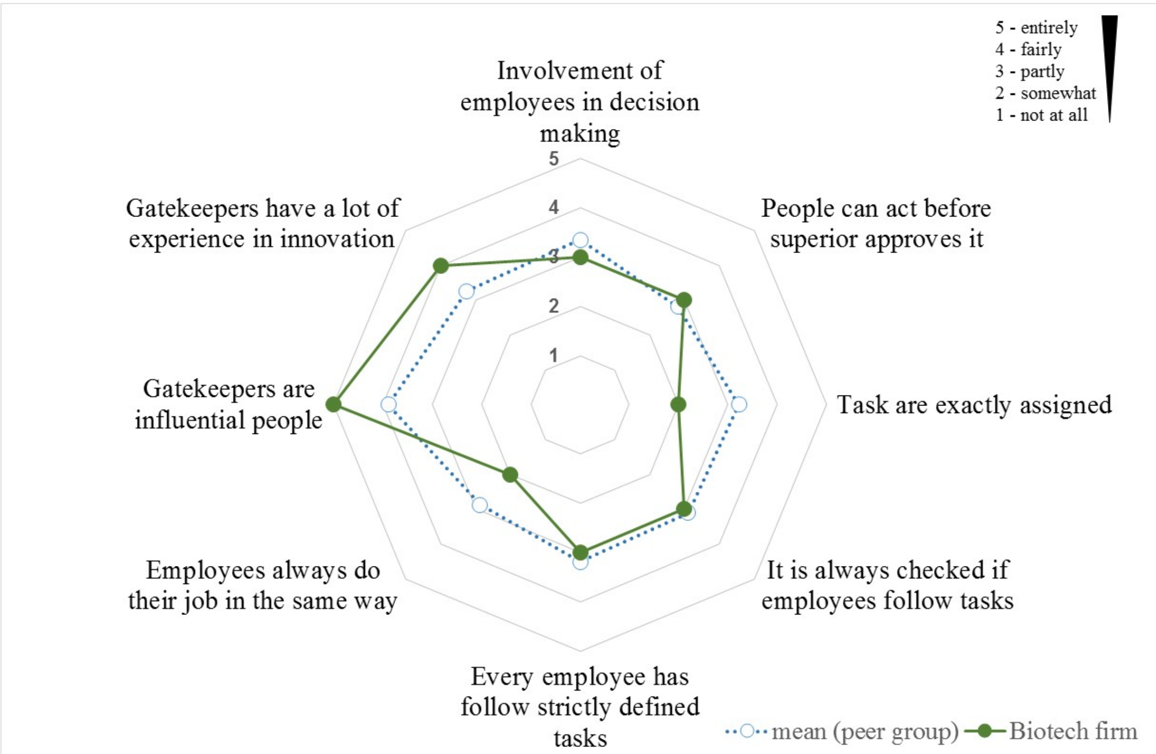

Figure 17: Expectation of organization concerning innovation behavior of employees

4.3.4 Outward looking and open innovation

Ideas for innovation does not necessarily have to originate internally only. There is also the possibility to collaborate with external partners such as customers, suppliers or even competitors. In this chapter it is evaluated, how important the OI concept is in the frame of the innovation process.

Figure 18 shows that marketing is only partly (3) to fairly (4) involved in the innovation process. Marketing and sales is rather integrated in all phases of the innovation process in the Biotech firm (4 versus 3.48). There the "market launch of innovation is already planned during development (4 versus 3.39) and marketing brings in the customer perspective in innovation process (4 versus 3.71). Moreover, in the Biotech firm marketing and sales do not often initiate innovation projects (3 versus 3.03). However, the benchmarked Biotech firm was ranked significantly lower for "feedback of customer is asked very early" (2 versus 3.58) and "marketing and sales has veto and can stop innovation process" (2 versus 2.87).

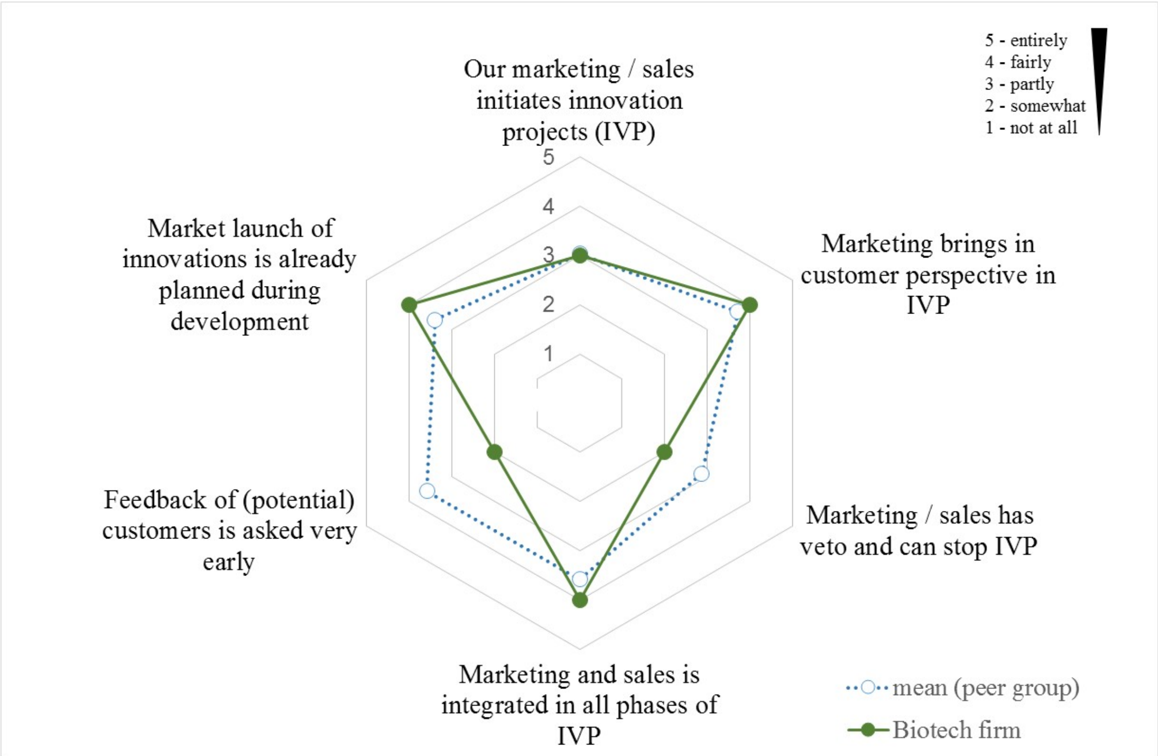

Figure 18: Involvement of marketing and sales in the innovation process

In general short term open innovation projects and activities are not very much pronounced in both, the peer group from Germany and the Austrian Biotech firm (Figure 19).

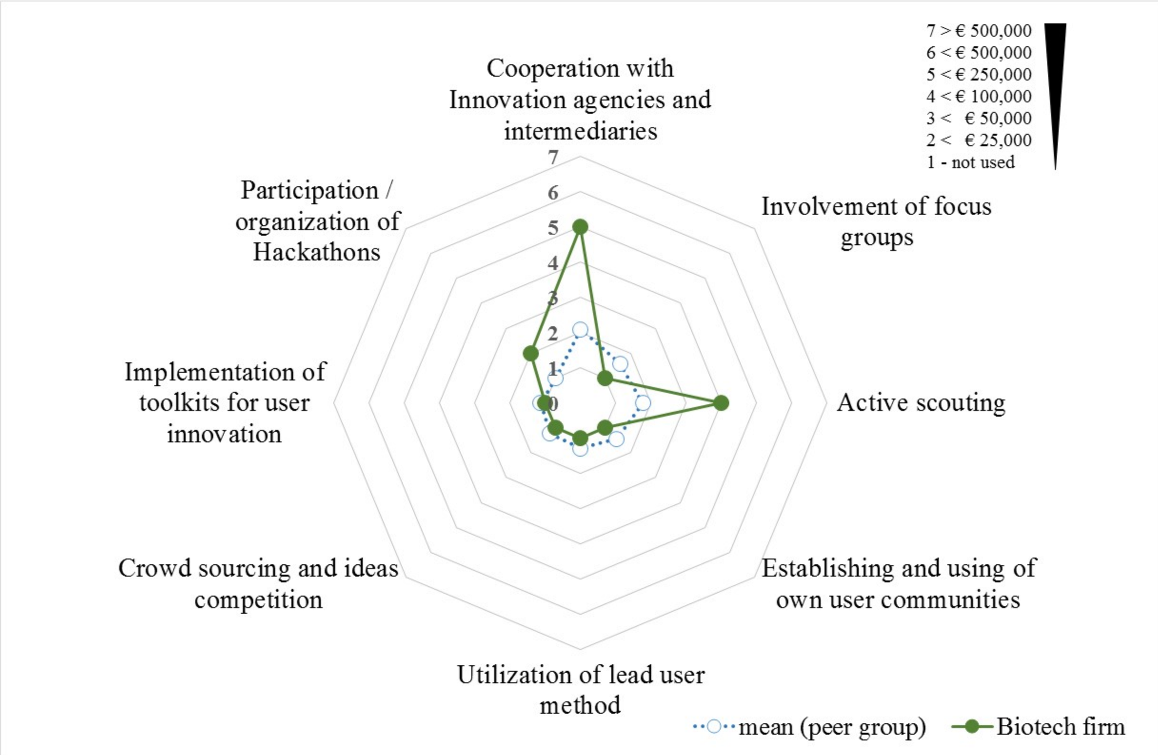

Figure 19: Short term projects and activities in the field of open innovation

Toolkits for user innovation, crowd sourcing and ideas competition, involvement of leader user and focus groups are not really used. The latter one is used a bit more intensively by the peer group. Cooperation with innovation agencies and intermediaries takes place partly (maximum 25,000 Euro) in the peer group and quite significantly in the benchmarked firm (maximum 250,000 Euro). It seems that active scouting is more intensively used in the Biotech firm (max. 100,000 Euro) compared to the peer group (maximum 25,000 Euro).

In the field of long term innovations, research projects with universities and research organizations are most pronounced for both, the peer group (average EUR 62,500 spending per year) and the Biotech-firm, which spends more than half a million Euro per year (Figure 20). "Formal innovation projects with suppliers" are the second most preferred long term collaboration (average yearly spending, peer group = EUR 26,613, benchmarking firm = EUR 50,000). "Formal innovation projects with competitors" is the most rarely used long-term innovation activity for the peer group (less than EUR 10,877 expenses) and "formal innovation project with supplier" for the Biotech firm (less than EUR 25,000 spending). In average the peer group spends more for collaborating with start-ups (EUR 58,065) compared to the Biotech firm (EUR 50,000).

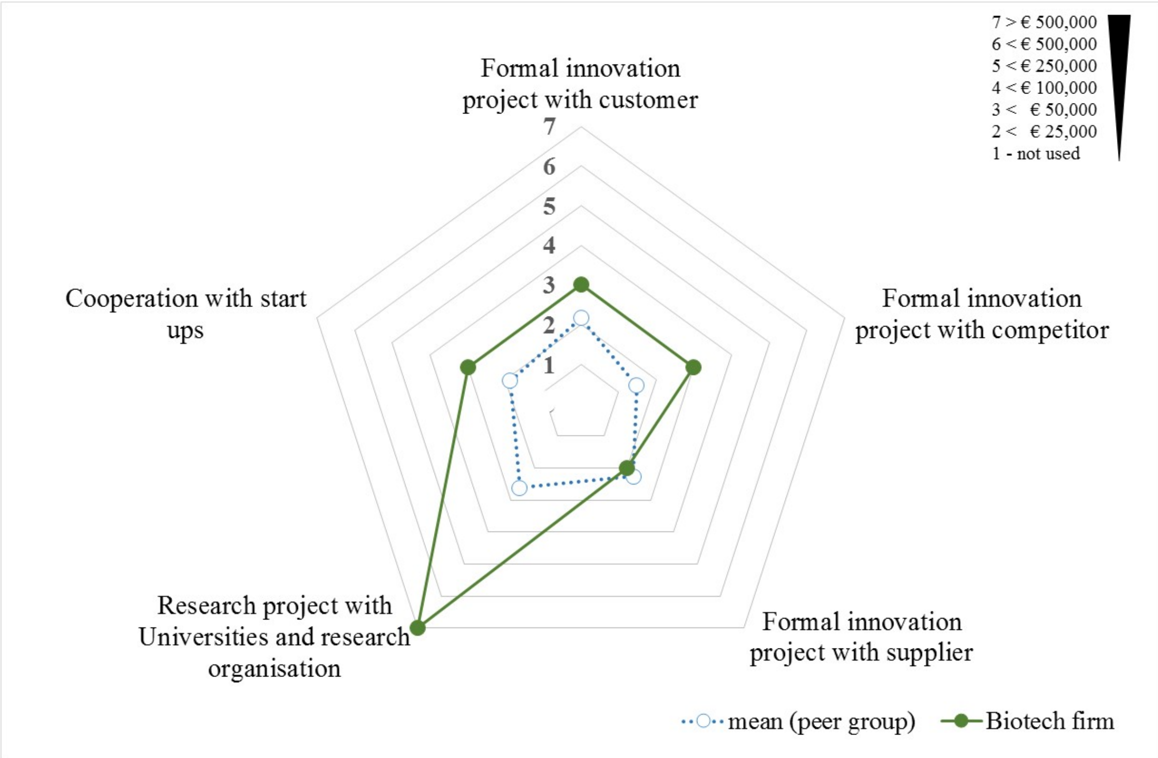

Figure 20: Long term projects and activities in the field of open innovation

4.3.5 Innovation success

An innovation is a success for a company if the investment of time, capital and creativity is transformed into an economic revenue. Therefore, from a business management point of view, innovation success can be assessed on basis of the contribution of the innovation to the company's success.

For the investigation of the innovation success, the peer group and the Biotech firm were asked about the distribution of revenues in the year 2016 between 1) existing products not changed during last three years, 2) new or improved products, but which competitors already have, 3) revenues of improved products and services and 4) revenues with products and services which are new to the market (Figure 21). For the Biotech firm only 11 percent of total revenues came from new or improved products or services, while this was 27 percent for the peer group. This 27 percent can be split into 10 percent of new products and services that competitors already have, 10 percent of improved products and 7 percent of products and services new to the market. The Biotech firm made 1 percent of its revenue with improved products and 10% with products and services which were new to the market.

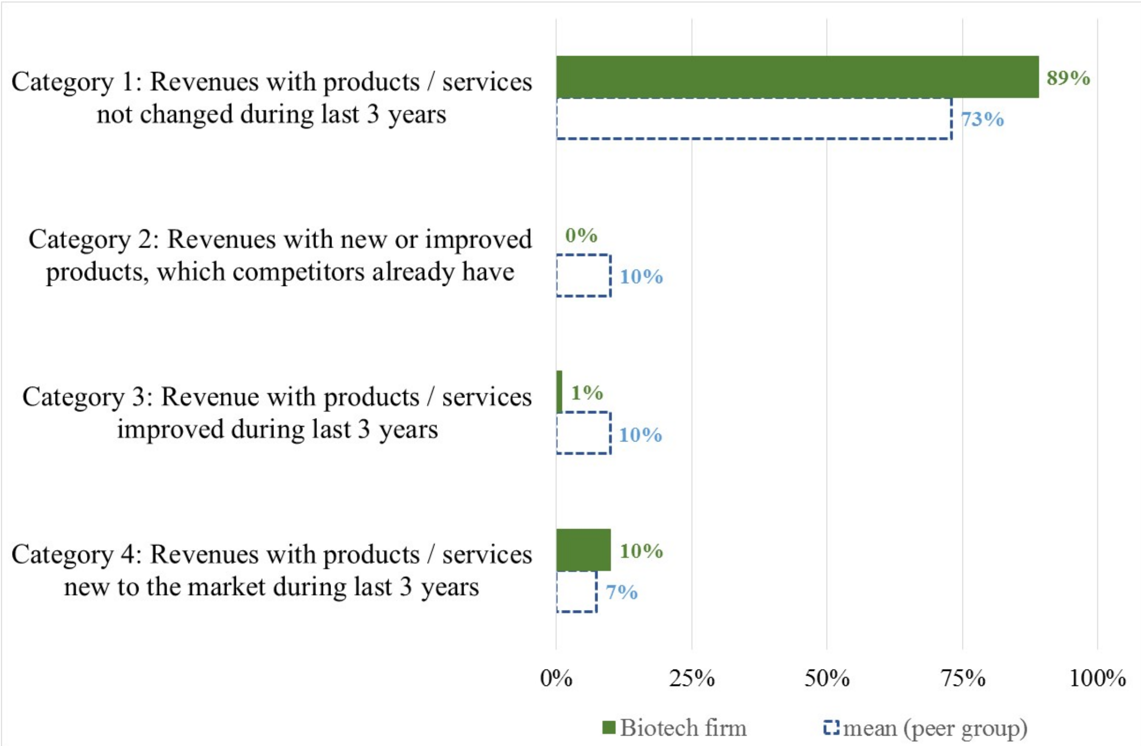

Figure 21: Split of product and service revenues into new and existing products and services

In average 8.3 percent of the peer groups innovations (category 1- category 3) were developed together with external partners. The Biotech firm developed all innovations together with external partners (data not shown).

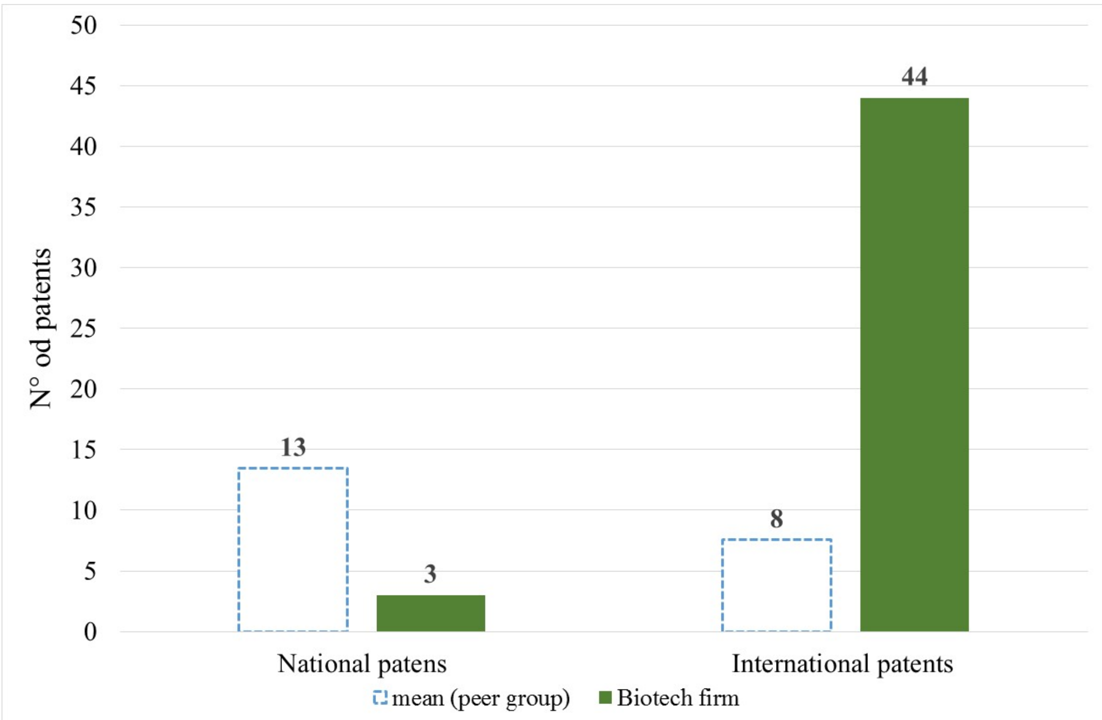

Figure 22: National and international patents granted in the period 2014 – 2016. 8 companies did not answer this question, 11 firms filed patents and 19 firms did not

Next to the share of novel products and services during the past three years also patents can be taken as an indicator for the innovation success of the companies (Figure 22). In average, the German peer group received 13 national patents compared to three of the Biotech firm in Austria. Latter one got 44 international patents granted compared to 8 of the peer group.

Hypothesis (H3) (*Differences between the management systems of the Biotech firm and a sample of German companies can be identified in a benchmarking analysis. Concrete recommendations can be made to foster cross sectoral learnings*) can be accepted as various differences in the IMP were discovered and improvements in the context of cross sectoral learning can be derived.

5. Discussion and future prospect

5.1 Implementation of OI in the peer group – theoretical and practical implications

This analysis was carried out to characterize the sample of German companies concerning their OI adoption rate. This is important as an Austrian Biotech firm was benchmarked against this groups of companies.

The literature shows a quite differentiated picture when it comes to the adoption of OI in organizations. Apart from geographic origin also the industry sector influences OI implementation rates. Furthermore, different basic information is used for the assessment of OI and a standardized method for a categorization is missing. For instance, some scholars suggest the extent of external technology acquisition and the extent of external technology exploitation as the two main dimensions of a firm's strategic approach to open innovation (Lichtenthaler and Ernst, 2009). In a study with 154 companies from Germany, Austria and Switzerland in total 47.4 percent of companies had implemented OI in their business (Lichtenthaler and Ernst, 2009). In a European-wide study (24 countries) covering different industries, 234 key informants (either CEO, managing director or R&D head) were interviewed. 31% of the responding firms were categorized as closed, 38.7% as semi-open and 30.3% as open. This study further revealed that "inbound open innovation is more commonly used than outbound open innovation, which can be explained by insufficiencies of the market or the organization. Finally, it was found that the type of innovation strategy (vertically integrated, inbound, outbound, or mixed) is related to the R&D intensity" (Schroll and Mild, 2011b).

PricewaterhouseCoopers (PwC)[8] surveyed over 1,200 executives in 44 countries concerning their innovation strategies. 61% out of 1,222 respondents said that they are using open innovation, 59% design thinking and 55% apply co-creation with customers, partners or suppliers (PwC, 2017). In our survey more than 91.4% (28 out of 31) of the interviewed companies indicated that they are involved in short term open innovation activities and 93.5% are engaged in long term innovation activities. However, as shown in Table 4 the extent of this short term collaborations is rather limited as the average spending of each of this short term open innovation activities except innovation activities with intermediaries

[8] https://www.pwc.com/us/en/advisory-services/business-innovation/assets/2017-innovation-benchmark-findings.pdf

(Appendix B 4.3.1a and Table 12) is less than 25,000 Euro. For cooperation with innovation agencies and intermediaries EUR 29,032 are invested in average. While 59% of the companies surveyed in the PwC study use "design thinking, in this study only 34% of the companies (11 out of 35) are regularly using this tool, but only to a small extent (mean value = 2.23, Figure 16). In this study the group of German companies invests an average amount of EUR 22,982 for formal innovation project with customers and EUR 26,613 for formal innovation project with suppliers (Appendix B 4.3.2). The PwC study shows that 55% of the interviewees mention co-creation with customers, partners and suppliers (PwC, 2017). In our survey 93.75% of the organizations did a formal innovation project with either their customer or their supplier. The average spending for this type of cooperation was EUR 49,597. In a study with data from 4,509 different firms in Germany belonging to the industry and service sector the degree of openness based on search breadth (number of different kinds of collaboration partners like suppliers, customers, competitors) and the importance and quality of these data was considered (Drechsler and Natter, 2012). According to the degree of openness measure, only 615 firms (25%) show a certain degree of openness in innovation. Hence, approximately 75% of the firms are not at all open in innovation. The authors of that study also concluded that the factors which prevent firms from being open are a lack of market and technological knowledge (knowledge gaps), ineffective intellectual property (IP) protection mechanisms and competitor threats such as market entries and imitation. Dahlander and Gann (2010) already postulated that assessing innovation opportunities and internalizing external knowledge requires some expertise. Furthermore, the most important factors that increase the degree of openness are a firm's need for financial funding in innovation and the effectiveness of a firm's IP protection mechanisms (Drechsler and Natter, 2012). A 2013 executive survey "Managing Open Innovation in Large Firms[9]" found that 78% of firms reported practicing open innovation. The survey included American and European organizations with annual sales in excess of US$ 250 million (Chesbrough and Brunswicker, 2013; Chesbrough and Brunswicker, 2014). A Spanish study reports that 20.6 per cent of firms are open innovators, 34.8 per cent are semi-open innovators and 44.5 percent are closed innovators (Barge-Gil, 2010).

[9] http://openinnovation.gv.at/wp-content/uploads/2015/08/Fraunhofer-2013-studie_managing_open-innovation.pdf

The change process from closed to open innovation is rated as the most difficult task (Chesbrough and Brunswicker, 2013). Comparing the OI adoption rate obtained in different studies reveals that there is a huge range of OI adoption from 25 to 75 percent (Table 8).

Table 8: Comparison of open innovation adoption rates from different studies

Study	**Sample size**	**Industry**	**Country**	**OI adoption rate* in %**
Lichtenthaler and Ernst (2009)	154	Medium and large firms	Germany, Austria, Switzerland	47.4
Drechsler and Natter (2012)	4,509	Various	Germany	25
Schroll and Mild (2011b)	234	Various	24 European countries	69
PricewaterhouseCoopers (2017)	1,200	Various	>40	61
Chesbrough and Brunswicker (2014)	125	Various, large firms	USA and Europe	75
Barge-Gil (2010)	10,875	Small, medium and large firms, manufacturing	Spain	55.4
Schatzmayr (2018)	38	Small, medium and large firms; different sectors	Germany	28.5

** semi- or fully adopted*

One of the main reasons is that there is a lack of a common standard in defining an OI adoption rate. Different measures were used in the studies mentioned and therefore the direct comparability is limited. Additionally, the OI adoption varies from industry to industry and there is also a time component involved as the referenced studies were carried out in a time period of around fifteen years. It has been described that since the first publication of OI different industries have been increasingly implementing OI (Chesbrough and Brunswicker, 2013). Schroll and Mild (2012) stated that "measurement of open innovation adoption requires measuring individual adoption activities and measuring the level of each activity is complicated because they are often diffusely organized within a firm and organized very differently in different firms. Because of resource constraints, studies are therefore usually limited to subjective measurement scales". In this study 28.5 percent of companies are full or medium adopters of OI, but it has to be noted that the number of respondents was quite limited which might impair the value of the evaluation. However, the result is quite comparable to Drechsler and Natter (2012), who also investigated a much bigger sample of German companies (4,509) but found a similar OI adoption rate of 25 percent. The questions is, why are still 25 to 75 percent of companies closed innovators? One of the reasons is that the implementation is not straight forward. A three phase process that comprises the stages of unfreezing, moving and institutionalizing has been suggested. Moreover, it emerges that the changes through which OI has to be implemented involve four major dimensions, i.e. networks, organizational structures, evaluation processes and knowledge management systems (Chiaroni et al., 2011). In another study undertaken with 107 small to large enterprises in 2008 it was found that loss of knowledge (48%), higher coordination costs (48%), as well as loss of control and higher complexity (both 41%) were mentioned as frequent risks connected to open innovation activities. In addition, there are significant internal barriers, such as the difficulty of finding the right partner (43%), imbalance between open innovation activities and daily business (36%) and insufficient time and financial resources for open innovation activities (Enkel et al., 2009).

It can be summarized that 28.5 percent of the sample of German companies in this study have adopted open innovation activities in their business processes.

5.2 Factors supporting OI and its influence on innovation success

For the correlation analysis subjacent questions of categories of the five chapters (innovation supportive management, innovation culture and climate, etc.) were used and averaged for each respondent. The reason for this approach was that the number of respondents was too low for a more in depth statistical analysis based on single questions. The answers of a selected set of questions from a category were averaged for each company and used for the correlation analysis. For the open innovation activities, in total twelve questions were averaged (see Method section). For the innovation success the revenue growth over a period of four years and the percentage of revenues with incrementally improved and new products during the past three years were used. Two different correlation analyses were performed (parametric- and non-parametric) as it was decided not to remove any data from the analysis. As already stated above, the number of respondents was low and at the same time the range of companies with respect to size and industrial sector was rather broad. The summary of the correlation coefficients (Pearson’s and Spearman’s) are displayed in Table 9. It can be seen (Figure 7, Table 9) that only one interaction resulted in one statistically significant correlation, namely between the application of OI tools and methods and innovation success based on the percentage of revenue with new and improved products (PR = 047; SR = 0.43).

Table 9: Summary of Pearson's (PR) and Spearman's (SR) correlation coefficients Determinations of correlations between different elements of the IMP with open innovation activities of a sample of 31 German companies

Pearson Correlation Coefficient (R)	OI activities	
	Pearson's (PR)	Spearman's (SR)
Innovation supportive management	0.01	0.10
Innovation climate – company perspective	0.09	0.29
Innovation climate – employee perspective	0.05	0.24
Innovation success	0.47**	0.43**
Formal innovation process	0.09	0.33*
Formal innovation process / instruments	0.33*	0.31*

*** significant on 5% significance level; * significant on 10% significance level*

The results of the correlation analyses were also confirmed with a regression analysis. It is obvious that the application of OI also improves the business performance of a company. This is also supported by other scholars who stated that there is common agreement that a proper implementation of the OI concept entails a financial advantage for organizations, however, it is difficult to assess the exact magnitude (Enkel et al., 2009). Procter and Gamble announced that they were able to increase their product success rate by 50% and the efficiency of their R&D by 60% by introducing the open innovation concept to the organization (Enkel et al., 2009). A study from Belgium underlines the importance of OI as it was found that, "in particular, technology alliance portfolio diversity has a positive impact on internal innovation efforts, which increases product innovation performance" (Faems et al., 2010).

Although a clear correlation between OI and the percentage of revenue with new or improved products (innovation success) could be observed in this survey it has to be kept in mind that the OI adoption rate of the sample of German companies generally was rather low. It also has to be considered that the innovation efficiency might be jeopardized if too many OI activities take place at the same time. For instance, open innovation via external collaboration is found to have a curvilinear relationship with innovative efficiency, taking an inverted U-shape (Fu, 2012, Laursen and Salter, 2006). This was not the case in this study, as the OI adoption rate in the sample of German companies was rather low (Table 5). There is a clear need to better engage in OI, however, the change from the closed to the open innovation paradigm is not an easy one. In a survey with large companies the implementation path of OI was found to depend on (1) innovation needs, (2) the timing of the implementation and (3) the organizational culture. Each of these factors led to differences in how OI was implemented (Mortara and Minshall, 2011). Concerning *innovation needs* it makes a difference if the firm is looking for ambidexterity (pursuing both, evolutionary and revolutionary change at the same time) or only for support of its current innovation pipeline. Concerning *timing of implementation* there is a clear difference between firms that implemented OI as a result of the publication of the model and those that had established OI activities previous to it. The first established a more centralized model, the latter decentralized OI activities. The *organizational culture* definitely is a strong factor as the firm's cultural background can overrule the other implementation drivers (Mortara and Minshall, 2011). Interestingly, in this study no correlation could be found between the innovation culture, from the firms' and the employees' perspective and the adoption of OI activities and methods (Table 9, Figure 7). The limited amount of data in this study is probably not sufficient to draw the conclusion that there is no connection between innovation culture and OI adoption. Probably this pattern would look differently if the sample of German companies would have been larger. Burcharth et al. (2014) report the importance of the culture in the organization and the management as such to support open innovation practices. Although the support of OI in the organization by the management is certainly crucial, no positive correlation could be found in this study (Figure 7, Table 9). This is surprising because T-MGMT in this study seems to be quite innovation supportive with an average scoring between 3.47 and 4.21 for the questions related to management (Appendix, B1.1). The positive attitude towards implementation of OI is also supported by Chesbrough and Brunswicker (2013) who found in their survey that 71 % of the respondents report that top management support for open innovation is increasing in their firm. However, T-MGMT also has to sustain organizational performance by effectively exploring and exploiting, which is managing strategic contradictions (Smith and Tushman, 2005). Again, the reason for not finding any correlation could be due to the limited sample number of companies, the different sizes and their affiliation to different industrial sectors. A larger number of samples would have allowed to categorize the companies according to their size and industrial sector. The latter one would probably have led to a positive correlation, as a positive relationship between company culture and innovation performance has been described by several scholars. A study from Canada found out that having innovation as a core part of a company's strategy and fostering a climate for innovation positively affects the degree of innovativeness and performance of a company. A climate for innovation is characterized by high levels of autonomy and encouragement, team cohesion, openness to change and risk taking and sufficient resources available to people (Crespell and Hansen, 2008). Another study reports that a supportive climate for innovation effectively discriminates between the best and worst performer (Cooper et al., 2004). It was also found out that highly innovation-supportive cultures are credited with fostering teamwork, promoting risk-taking and creative actions that seem directly linked to effective new product development (Jassawalla and Sashittal, 2002). It can also be assumed that cultures vary in different industrial sectors. This needs to be considered for an analysis and conclusion drawn thereof. For example, the results of a survey with 11,789 individuals in 77 companies in the US corroborate the existence of cultural practices that are industry or `industry type' specific and that variations in revenue growth within industry types are associated with practices different from those characterizing the industry type culture (Christensen and Gordon, 1999). Next to organizational culture also management style is a crucial factor affecting the development of entrepreneurial and innovation behavior in organizations (Fu, 2012). This is also confirmed by other scholars who reported that the role of top management in planning for and executing an innovation strategy is key to a firm's financial performance (Crespell and Hansen, 2008). Conversely it was reported from a study with a sample of 429 employees from small to medium sized manufacturing firms that there is no direct relationship between an innovative culture and firm performance. However, when the competitive environment was changing rapidly, firm earnings were enhanced by an innovation culture (Chandler et al., 2000).

Another question in this study was if there is a correlation between the existence of a formal IMP and adoption of OI. It could be observed that there is a positive trend ($P < 0.1$) between the formal innovation process and the application of OI methods and activities (Table 9, Figure 8). Especially the positive trend between adoption of OI practices and the formal innovation process (instruments) seems to be quite obvious as many of the tools surveyed in this study (e.g. lead user approach, blue ocean method, etc.) can be directly linked to OI (Appendix, B 3.3). Of course, open innovation is not much formalized yet, and cultural norms are as important for open innovation as formal practices (Chesbrough and Brunswicker, 2013). However, it was suggested that firms can benefit from opening up the NPD process by integrating the principles of open innovation with the well-known and widespread Stage-Gate process for organizing NPD (Grönlund et al., 2010). As mentioned before, two ways to stimulate innovation have been suggested, culturally by creation of an innovative climate and structurally, by a systematic use of innovation mechanisms. The structural approach towards enabling innovation concerns the organized use of enabling innovation mechanisms. Innovation mechanisms are organizational entities designed to promote the development and management of new ideas, projects and business. Well known examples of innovation mechanisms include champions, task forces, venture teams, skunk works, spin-offs, enabling acquisitions, spin-ins, venture capital, licensing, innovative budgets, partnering, listening posts, among many more (Van Der Meer, 2007). This means that innovation and in particular open innovation activities can be stimulated and guided by formal innovation processes. Not only large companies but also SMEs are adopting open innovation practices, but there is no difference between manufacturing and service industry, but medium sized firms are on average more heavily involved in open innovation than their smaller counterparts (van de Vrande et al., 2009). The sample size in this survey with 38 respondents was too small to analyze any differences in the OI adoption rates of small- , medium- and large-sized enterprises. "In a study with 180 European firms the adoption of open innovation was linked with organizational capabilities, characteristics of the market environment and human capabilities. The results indicated that open innovation adoption is strongly dependent on the level of technology and the level of hostility in an industry. It was concluded that organizational variables like the strategic breadth and human capabilities have significant influence on the adoption of open innovation strategies" (Schroll and Mild, 2011a). When it comes to OI implementation it has to be kept in mind that the saying *more is not always better* is also true for the OI paradigm. Laursen and Salter (2006) stated that if the search breadth is too wide, OI strategies can become costly. Therefore, the implementation of the new paradigm needs to be monitored and controlled to be able to come to conclusions concerning the success of the implementation. If no metrics or insufficient metrics are used, it will remain an open question which actions have to be taken to increase the chances of successfully employing the open innovation strategy. Therefore various metrics, from single indicators to combining the open technology roadmap with the open innovation scorecard were proposed (Brau et al., 2013). Using these measures and techniques allows a firm to empirically assess the implementation process of the open innovation strategy.

Referring to **RQ1** it can be said that there was a statistically significant correlation between adopting OI activities and methods and innovation success (new and improved products) and that the existence of a formal innovation system has a positive relationship with OI in the sample of German companies. However, the latter one is only significant on a significance level of 0.1 percent. No positive correlation could be observed between implementation of OI activities and innovation climate and innovation supportive management, respectively.

5.3 Cross-sectoral learnings of a Biotech firm from a German peer group

Quantifying, evaluating and benchmarking innovation competence and practice is a significant and complex issue for many contemporary organizations. An important challenge is to measure the complex processes that influence the organization's innovation capability, in order that this organization can be optimally managed (Frenkel et al., 2000, Adams et al., 2006).

For this benchmarking analysis a questionnaire consisting of five main chapters was the basis. Each main chapter consisted of different categories with subjacent questions. For the benchmarking of the Austrian Biotech firm against a sample of up to 38 German companies radar charts were drawn to visualize the results of the individual questions (see figures in section 4.3). Anyhow, to start with a more global analysis of the results the averages of the answers of the categories were taken and compared with the results of the Biotech firm. In Table 10 differences between the peer group and the Biotech firm are highlighted with two different colors. Green was used for those categories were the Biotech firm received a better evaluation compared to the respective average of the German peer group. The red color indicates those categories where the peer group outcompeted the Biotech firm. When the differences were smaller than +/- 0.1 or +/- 5 percentage points the results were interpreted as equal (no color code used).

In the chapter **innovation supportive top management** the Biotech firm performed better concerning the "commitment of management spent in innovation activities" (36.7 versus 32.3) and "organization and content of innovation strategy" (3.11 versus 2.39). The peer group performed better with regard to the "management's engagement in innovation projects" (peer group: 3.86; Biotech firm: 3.60). Looking at the subjacent questions room for improvement can be clearly seen for "support and motivation of innovation teams" (Δ = - 0.97) and "communication of the importance of external partners" (Δ = - 1.47).

Table 10: Summary of the survey for benchmarking purposes based on averages of the categories

Main chapter	Category	Code*	Peer group average	Biotech firm
Innovation supportive top management	Engagement in innovation projects	B 1.1	3.86	3.60
	Commitment of management in days	B 1.2	32.3	36.7
	Organization and content of innovation strategy	B 1.3.1 B 1.3.2	2.39	3.11
Innovation climate	Innovation focus and initiatives of employee (company perspective)	B 2.1 B 2.2	3.78	3.83
	Innovation climate in % (employee perspective)	B 2.3	37	53
Innovative processes and organization	Continuous observation of market, technology and competitors	B 3.1	3.65	4.00
	Design and configuration of innovation process	B 3.2a B 3.2b	3.12	3.96
	Instruments and methods	B 3.3	2.65	2.38
	Organizational design	B 3.4.1 B 3.4.3	3.21	3.13
Open Innovation	Involvement of Marketing & Sales	B 4.1 B4.2	3.36	3.17
	Short term initiatives in OI in EUR	B 4.3.1	8,468	46,875
	Long term initiatives in OI in EUR	B 4.3.2	36,210	135,000
	Support of employees innovation potential in days	B 2.4.1 & 2	3.84	2.43
	Motivation of employees innovation potential in % of Yes	B 2.4.3 & 4 & 5	32	33
Innovation success	Revenues with new or improved products in %	B 5.1.1	27	11
	National and international patents	B 5.4	21	47

**Details are shown in Appendix under respective question N°*

Although the Biotech firm performed better in the category "organization and content of the innovation strategy" (3.11 versus 2.39) for one of the underlying questions the peer group had a higher rating, namely for "communication of innovation strategy to employee". This is remarkable because even the result of the peer group is low (2.39), but those of the benchmarked firm is even lower (2.0). This might indicate that the communication of IS to employees is a neglected task of management in many firms. Regarding questions in the chapter **innovation climate** the Biotech firm was ranked similar for "innovation focus and initiatives of employees" (3.83 versus 3.78) and higher for "innovation climate from employees' perspective" (53% compared to 37%). Even though the Biotech firm was ranked similar for the first category, it was significantly below its peer group with regards to: “Learning from mistakes and failures” (Δ = - 1.71) and “innovative people get promoted more quickly” (Δ =- 0.66). While the first one needs to be taken seriously as organizational learning is an important pillar of a successful innovation system (García-Morales et al., 2012), the second one can be interpreted in a different way, because in a very innovative environment with many innovative employees other factors might also be decisive for promotions. In a US study it was found out that *no punishment for failure* and *removal of fear of failure* is particularly evident in the best innovation performing group in order to encourage more innovative and risk-taking behavior. Actually 55.2 percent of Best Performers do not punish people for failure in NPD. By contrast, 34.6 percent of Worst Performers display an exceptionally high fear of failure (Cooper et al., 2004).

For the second category “innovation climate from employee perspective” one negative skewness is obvious: 39% of the peer group agreed that “lateral thinking and unconventional ideas are supported” whereas in the Biotech firm only 25% of the employees agreed. The goal is to turn the creative power of people in an organization into opportunistic entrepreneurs who are constantly looking for a new way of doing things. This is where lateral thinking comes in. It means approaching business challenges from new directions in order to conceive radical and better solutions. The key is for the leader to encourage and develop lateral thinking skill in his or her team (Kuesten, 2008). According to the rankings of “continuous observation of market, technology and competitions” it seems that the Biotech firm is doing a little better (Δ = - 0.35). Concerning the idea management system it can be recognized that the Biotech firm has a much higher number of ideas per person and year (0.35) compared to the average of the peer group (0.05). Anyhow, there is a debate if for a good idea management system the number or the quality of ideas is more important (Reinig and Briggs, 2008). It is needless to say that good ideas are only useful if they are implemented and scholars suggested that idea generation should only be seen as one of three steps in the innovation value chain next to conversion and diffusion (Hansen and Birkinshaw, 2007).

Regarding the chapter **Innovative processes and organization** the Biotech firm had higher average rankings for “continuous observation of market, technology and competitors” (4.00 versus 3.65) and for “design and configuration of innovation processes” (3.96 compared to 3.12). Out of the 15 underlying questions only for “our processes optimally support radical innovations” the Biotech firm was ranked below the German peer group (Δ = - 0.48). From an empirical study it was reported that factors favoring radical innovation include environmental dynamism, intrafirm linkages, experimentation, and transitioning or sequencing from one project or product to another (Koberg et al., 2003). Although the average ranking of the German peer group was rather low for the eight questions in the category instruments and methods (2.65) it was way better than that of the Biotech firm (2.38). Especially for the applied methods the Biotech firm stayed behind the peer group. “Blue ocean“, “lean start-up method” and “design thinking” is not used at all by the Austrian firm, as each of these questions was ranked with 1. At least “agile processes” like Scrum seems to be used sometimes. However, both, the German peer group and the Austrian Biotech firm were rather poor users of quite common instruments of innovation processes. Regarding the category “organizational design” hardly any differences can be seen on the average evaluation which consisted of eight underlying questions. Anyhow, a more detailed look brings to light that the peer group had higher ranking for “involvement of employees in decision making” (Δ = - 0.35), “tasks are exactly assigned” (Δ = - 1.23), “every employee has to follow tasks” (Δ = - 0.19) and “employees always do their job in the same way”. While an insufficient involvement of employees in decision making might reduce the motivation and impair the innovative culture, the other three questions do not affect the innovation culture. In contrary, if employees have more freedom how to organize their tasks and working environment this could increase their motivation and improve the innovation culture.

In the **open innovation** chapter the peer group received a higher ranking based on the averages for all subjacent questions for “involvement of Marketing & Sales” (3.36 versus 3.17) and “support of employees’ innovation potential” (3.84 versus 2.43). For two of the marketing and sales relevant questions the Biotech firm remained behind the peer group: “Marketing / sales has veto and can stop innovation project” (Δ = - 0.87) and “feedback of (potential) customers is asked very early” (Δ = - 1.58). The importance of a veto role for marketing can be discussed controversially. On the one hand marketing is close to the customer but on the other hand this might lead to a situation where the potential for disruptive innovation might be neglected. However, at a certain point customers have to be involved in the innovation and therefore it can be seen quite critical that the Biotech firm has received such as low ranking for this question (2.00 versus 3.58). In the category of “support of employees’ innovation potential” the Biotech firm remained behind its peer group for all three questions: The Biotech firm invests 3.1 days less in training and education and also the ranking for specific OI education (Δ = - 0.62) and information of employee on OI was below its peer group (Δ = - 0.50). No difference between peer group and the Biotech firm could be observed, when all answers from the category “motivation of the employees’ innovation potential” were taken together. Except for “employee profit sharing plan” the Biotech firm was ranked like the majority of the firms in the peer group. The majority (74%) of firms has a “formal idea management system”, but “regulation for free time”, “internal venture capital”, “specific incentives for ideas from outside” or “specific incentives for collaborating with external partners” hardly exists as only 18 to 24 percent answered with “yes”. Findings from other studies suggest that long- and short term incentives both have significant positive effects on the innovation efficiency of firms with long term incentives having a greater effect than short term incentives. Moreover, such long term incentive schemes will also promote team working, which is crucial for innovation. Each agent will realize that the final success of a project, which is reflected in the value of stock and share options, depends not only on the performance of him/herself and his or her own department but also upon other people and departments in the firm. Such long term incentives not only motivate firms to engage in innovation activities but also promote strategic decisions, greater efforts throughout the innovation process, greater coordination and team working whilst also reducing shirking and free-riding (Fu, 2012). The average spending for “short- and long term OI activities and methods” is much higher in the Biotech firm compared to the peer group (short term: EUR 46,875 versus EUR 8,468; long term: EUR 135,000 versus 36,210). However, this seemingly superior result has to be put into perspective because the adoption of OI is in general very low in the peer group (see chapter 5.1). Even though the spending of the Biotech firm is much higher for short term OI activities, there are some methods which are not used at all like “involvement of focus groups”, “user communities”, “lead user method”, “crowd sourcing” and “toolkits for user innovation”. These methods, however, are very important in the context of OI (Elmquist et al., 2009; Keinz et al., 2012). In a survey in 2011 it was reported that establishing new partnerships, exploring new technological trends and identifying new business opportunities are the leading strategic reasons to engage in open innovation. Customer co-creation, informal networking and university grants are the three leading inbound practices. Joint ventures, selling market-ready products and standardization are the three leading outbound practices. Donations to commons and spin-offs play a minor role (Chesbrough and Brunswicker, 2013). The importance of including users in the innovation process was already described in the 1970 (von Hippel, 1976). “His key finding was that approximately 80% of the innovations judged by users to offer them a significant increment in functional utility were in fact invented, prototyped and first field-tested by users of the instrument rather than by an instrument manufacturer". In the category of long term "OI activities with external partners" all five activities are used by the Biotech firm, however, for "formal innovation projects with supplier" (Δ = - EUR 1,613) and "cooperation with start-ups" (Δ = - EUR 8,065) it remained behind the average expenses of the sample of German companies. The evaluation of the impact of cooperation with public research on firms' product and process innovations in France and Germany based on Community Innovation Survey[10] data from 2004-2008 showed that cooperation with public research increases production innovation, but has no effect on process innovation, which depends more on firms' openness (Robin and Schubert, 2013). This finding is especially important for the Biotech firm, as this company is seemingly very active in cooperation with external research institutions (> EUR 500,000 expenses), but rather closed for other long term cooperation possibilities, such as collaboration with start-ups and formal innovation projects with customers, competitors and suppliers. Chesbrough and Brunswicker (2013) reported from their 2011 survey that customers, universities and suppliers were the three leading open innovation partners reported by the respondents. This is in line with the current study were 24 companies of the peer group reported cooperation with universities, 23 with suppliers and 21 with customers. Co-creation with competitors was only mentioned by ten respondents (Appendix, Table 12). Furthermore Chesbrough and Brunswicker (2013) found out that crowdsourcing and open innovation intermediary services are rated lowest in importance. Data from the current study confirm that crowdsourcing is not widely used, because only 6 out of 38 companies stated to use this method. In contrary to the above mentioned study a quite high number of twenty companies used innovation intermediaries in this survey. A study based on data from Germany found that R&D activities were a main driver for innovation success if combined with external R&D, using external innovation sources or by entering into co-operation agreements. SMEs without in-house R&D can yield a similar innovation success if they effectively apply human resource management tools or team work to facilitate innovation processes (Rammer et al., 2009).

The main chapter **innovation success** consisted of two categories, one related to the percentage of "revenues with new or improved products" during a period of three years and the second based on the "number of issued national and international patents". For the latter

[10] http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey

one the Biotech firm had received 3 national and 44 international patents compared to 13 national and 8 international for the peer group. Interestingly only 11 companies from the peer group reported that they are involved in patenting, thus the given numbers are averages of eleven companies. Regarding the "percentage of revenues made with new and improved products and services" the Biotech firm is far behind the average of the German peer group. Only 11% of the revenues of the Biotech firm in the period 2014 – 2016 was made with new or improved product compared to an average value of 27% of the peer group. Since the innovation process is industry specific to a certain extent, innovation efficiency should be estimated by industry (Fu, 2012). This scholar found in his study with British firms that the average share of new products in total sales is 44 percent and that the average R&D expenditure to total sales ratio was 9 percent. Compared to the present study they report much higher values, the share of new product in this study was 27% for the peer group and 11% for the Biotech firm. Also the innovation rates for the German sample was 3.51% in average and for the Biotech firm 5.7% which is below the study from Fu (2012). However, it was noted that the British study has a limitation as the data are cross-sectional, which is also the case for the current study with the German companies. However, Fu (2012) states that despite the different advantages and disadvantages of various innovation measures, the percentage of sales due to new or significantly improved products picks up most of the quantity and quality aspects of organizations' innovation performance. Of course, the transformation of innovation inputs into successfully commercialized new products takes time. With regard to define a new product benchmark a study was undertaken by the American Productivity and Quality Center (APQC)[11], in association with Dr. Robert G. Cooper and Dr. Scott J. Edgett where they studied a range of medium to large businesses, from a number of different industries (around half manufacturing). This study measured new product performance in a number of ways, with performance data that can be used to benchmark any business's NPD. Regarding the most popular performance metric "percentage of sales revenue derived from new products" the overall average percentages for three-year new products was about 27.5 percent of sales and profits. Moreover, the results of the top 20 percent on these two metrics was 38 percent of sales and an even higher percentage of profits (42.4 percent) coming from new products (Unknown, 2004, Cooper et al., 2004). Interestingly the average percentage of sales with new or improved products is almost identical to the German peer group, however, the Biotech firm is lagging behind.

[11] https://www.apqc.org/

Anyhow, it seems that there is no correlation between the innovation success based on revenue share with new products and the revenue growth as the sample of German companies grew 28% in revenues from 2012 to 2016 whereas the Biotech firm grew 78% (Table 3). Again the different sectors need to be considered in this benchmarking study – obviously it takes much longer in the Biotech field to get new products registered in various markets which is then reflected in the higher percentage of “older” products. Those areas where the Biotech firm was ranked below the peer group are summarized in Table 11. Furthermore it was assessed how important the respective deviation should be taken when it comes to improvement and also possible improvement steps are suggested.

Table 11: Summary of areas were Biotech firm was rated lower than peer group

Question	Δ*	I **	Possible improvement steps
Support and motivation of innovation teams	-0.97	++	Management regularly participates in innovation project meetings. Updates of innovation projects are regularly reported in Board meetings
Communication of importance of external partners	-1.47	+	Creating awareness that external partners are crucial in the innovation process
Communication of innovation strategy to employees	-0.39	++	By using internal communication channels the innovation strategy can be communicated which increases motivation of employees. IS should be included in company roadmap
Learning from mistakes and failures	-1.71	++	More systematic approach towards capturing and communication learnings from mistakes and failures in all processes. Reflecting on mistakes and failures should be formalized in project management in all areas
Innovative people get promoted more quickly	-0.66	~	Doesn’t seem the most important criterion for promotion in a quite innovative environment where innovation is widely spread amongst employees
Lateral thinking and uncon-ventional ideas are supported	-14%	+	The implementation of lateral thinking should be considered
Our process supports radical innovations	-0.48	+	Awareness for radical ideas and innovations in the frame of the formal innovation system should be created
Blue ocean method	-1.19	~	Evaluation if this method can be used in the Biotech environment
Lean start up method	-1.26	~	Evaluation if this method can be used in the Biotech environment
Agile process	-0.65	~	Evaluation if this method can be used in the Biotech environment

Design thinking	-1.23	~	Evaluation if this method can be used in the Biotech environment
Involvement of employees in decision making	-0.35	++	This can be combined with the deeper involvement of management in innovation project meetings
Tasks are exactly assigned	-1.23	~	In an innovative environment flexibility is important – it seems that there is no need for change
Employees always do their jobs in the same way	-0.87	~	In an innovative environment flexibility is important – it seems that there is no need for change
Sales and marketing has veto and can stop innovation project	-0.87	+	Probably nothing has to be changed, as marketing is anyway involved in the stage gate process
Feedback of potential customers is asked very early	-1.58	++	Very important component in the innovation process which should be implemented in the IMP
Various short term OI methods	EUR -2,823 – -8,065	~	Short term innovation methods should be further evaluated in the context of the respective Biotech environment
Formal innovation project with suppliers	EUR -1,613	+	Involvement of suppliers in innovation projects should be considered
Cooperation with start-ups	EUR -8,065	+	Should be further evaluated
Education of employees of OI	-0.62	+	Should be increased in order to improve the OI culture in the company
Information employees on OI	-0.50	+	Should be increased in order to improve the OI culture in the company
Revenues with new or improved products	-16%	++	Many aspects of the IMP need to be improved in order to improve this indicator. The implementation of an innovation BSC could facilitate the improvement of this indicator in a time frame of a couple of years

**difference in evaluation between Biotech firm and peer group; ** I= Importance: ++ = very important, + = important; ~ less important*

Referring to **RQ2** it can be concluded that based on more than 100 questions belonging to 16 categories the Biotech firm achieved a better ranking in eight categories and the peer group in average performed better in five categories. For three categories no difference could be observed. Furthermore twenty-two questions regarding tools, methods or behaviors were identified where the peer group in average achieved a higher ranking. Out of these twenty-two, six question were ranked very important for a follow up in order to improve the innovation management system of the Biotech firm. Possible improvements for the areas where the ranking was below the peer group were suggested.

6. Theoretical and practical implications and limitations

This study contributes to the research in the field of open innovation, in particular the effect of innovation supportive management, innovation climate and organization of innovation on the adoption of OI and its impact on innovation success. Furthermore the benchmarking part of this study reveals many differences between a peer group and the Biotech firm which can be used in an organizational learning context.

It could be observed that the OI adoption rate is lower than expected and that T-MGMT and innovation climate did not significantly influence using OI methods and in general engaging in OI. This result was not expected and an explanation could be the low sample number (only 38) of companies in this study and their heterogeneity (huge variation in size and allocation to different industrial sectors). Concerning OI adoption rate is has to be noted that different methods are used to differentiate the implementation of OI and therefore the comparison of the obtained results with information from literature is quite challenging. More studies are needed to harmonize the methods which are used for determining the OI adoption rate. Although the OI adoption rate of the peer group was low, a correlation between OI and innovation success could be observed. This is an interesting contribution as there are not that many studies which are able to prove the direct impact on using OI and the percentage of revenues with new or improved products. Another limitation of this empirical study is that it is not exactly known how accurately the respective respondent filled out the questionnaire and if all the necessary information was available in the organization. For instance, it could be observed that for some organizations the values for innovation rate do not match with the investments in OI. In the benchmarking study valuable information could be gained for both, the peer group and the Biotech firm which will help to improve the innovation management processes. However, no general recommendation for improving the IMP for Biotech firms can be made as no other organization from this industrial sector was in the peer group.

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Appendix

Descriptive statistic of questions

Questions B 1.1 Innovation supportive top management	mean	median	N	min	max	Biotech	Δ*
Definition of goals	3.89	4	38	1	5	4	0.11
Monitoring of progress	3.76	4	38	1	5	4	0.24
Delegation to innovation teams	4.21	4	38	1	5	5	0.79
Support and motivation of innovation teams	3.97	4	38	1	5	3	-0.97
Communication of importance of external partners	3.47	4	38	1	5	2	-1.47

**Difference of means of peer group and Biotech firm*

Questions B 1.2 Commitment of management	mean	median	N	min	max	Biotech	Δ*
Working time for innovation	11.91	10	38	2	30	20	8.09
Days of contacts with customers	78.82	65	38	1	250	75	-3.82
Continuing education with innovation relevance	6.17	5	38	0.5	20	15	8.83

Questions B 1.3.1 & 2 Organization and content of innovation strategy	mean	median	N	min	max	Biotech	Δ*
Follow concrete Innovation Strategy (IS)	2.66	2	38	1	4	3	0.34
Communication of IS to employee	2.39	2	38	1	4	2	-0.39
IS is continously adapted	2.55	2	38	1	4	3	0.45
Consider new business models and markets	2.82	3	38	1	4	3	0.18
Consider future customer demands	2.68	3	38	1	4	3	0.32
Identification and care of core competencies	3.13	3	38	1	4	4	0.87
Involvement of external partners in innovation	2.45	2.5	38	1	4	3	0.55
Proactive management externals and strategic alliances	2.47	2	38	1	4	3	0.53
Prognosis and consideration of disruptive innovations	2.16	2	38	1	3	4	1.84

Questions B 2.1 & 2 Innovation focus and initiatives of employees	mean	median	N	min	max	Biotech	Δ*
Company culture supports entrepreneurial and innovative activities	3.95	4	38	2	5	4	0.05
Learning from mistakes and failures	3.71	4	38	1	5	2	-1.71
Expect employees to communicate with externals	3.16	3	38	1	5	5	1.84
Employees are initiative. engaged and feel self-responsible	3.61	4	38	2	5	4	0.39
With good ideas employees can contact management	4.58	5	38	2	5	5	0.42
Innovative people get promoted more quickly	3.66	4	38	2	5	3	-0.66

Questions B 2.3 Innovation climate - employee perspective	mean	median	N	min	max	Biotech	Δ*
Working place is inspiring for innovation	28%	25%	35	2.5	80	55%	27%
Improving processes is part of my job	33%	25%	35	4	100	40%	7%
Enough time/room for innovation	28%	20%	35	2	100	45%	17%
My superior is very interested in my suggestions	40%	35%	35	5	90	60%	20%
If my proposal is good I can be sure it will be taken serious	50%	50%	35	4	100	75%	25%
Lateral thinking and unconventional ideas are supported	39%	30%	35	0	100	25%	-14%
(Constructive) criticism is appreciated	41%	40%	35	0	100	40%	-1%
Innovative and entrepreneurial people can make career	33%	25%	35	0	90	45%	12%
Failures are accepted (if innovative idea fails)	49%	40%	35	2	100	80%	31%
That’s the most innovative firm I've ever worked for	30%	20%	35	0	90	60%	30%

Questions B 3.1 Continuous observation of market, technology and competition	mean	median	N	min	max	Biotech	Δ*
Development in the marked are systematically observed	3.65	4	31	2	5	4	0.35
Information of market monitoring are used for strategic decisions	3.65	4	31	1	5	4	0.35

Questions B 3.2a Design and configuration of innovation process	mean	median	N	min	max	Biotech	Δ*
Short decision making process	3.55	4	31	1	5	4	0.45
Systematic innovation process - from idea to market	3.16	3	31	1	5	5	1.84
Flexibility of innovation process	3.81	4	31	1	5	4	0.19
For each phase of process goals are defined	3.10	3	31	1	5	5	1.90
Realization of goals is evaluated after each phase	3.19	3	31	1	5	4	0.81
Go / kill decision after each phase	3.35	4	31	1	5	4	0.65
Interests of all processes in the company are considered	3.52	4	31	1	5	5	1.48

Questions B 3.2b Design and configuration of innovation process	mean	median	N	min	max	Biotech	Δ*
Methods and instruments for collaboration with externals is available	2.13	2	31	1	4	4	1.87
Innovation teams comprise members of different divisions	3.77	4	31	1	5	4	0.23
Our processes optimally support incremental innovations	2.87	3	31	1	5	4	1.13
Our processes optimally support radical innovations	2.48	2	31	1	4	2	-0.48
Good mix between incremental and radical innovations	2.81	3	31	1	5	3	0.19
Good mix between short- and long term projects	3.13	3	31	1	5	4	0.87
Ideas of external sources have same chance	3.45	3	31	2	5	4	0.55
Project management software / real time	2.26	1	31	1	5	3	0.74

Questions B 3.3 Instruments and methods	mean	median	N	min	max	Biotech	Δ*
Project management	3.77	4	31	1	5	4	0.23
Stage Gate Process	2.58	2	31	1	5	4	1.42
Business Modell Canvas	2.39	2	31	1	5	3	0.61
Blue Ocean method	2.19	2	31	1	5	1	-1.19
Lean start-up method	2.26	2	31	1	5	1	-1.26
Agile process (e.g. Scrum)	2.65	2	31	1	5	2	-0.65
Design Thinking	2.23	2	31	1	4	1	-1.23
Risk and scenario analysis	3.13	3	31	1	5	3	-0.13

Questions B 3.4.1 & 3 Organizational design	mean	median	N	min	max	Biotech	Δ*
Involvement of employees in decision making	3.35	3	31	2	5	3	-0.35
People can act before superior approves it	2.81	3	31	1	5	3	0.19
Task are exactly assigned	3.23	3	31	1	5	2	-1.23
It is always checked if employees follow tasks	3.10	3	31	1	5	3	-0.1
Every employee has follow strictly defined tasks	3.19	3	31	2	5	3	-0.19
Employees always do their job in the same way	2.87	3	31	1	5	2	-0.87
Gatekeepers are influential people	3.89	4	19	2	5	5	1.11
Gatekeepers have a lot of experience in Innovation	3.26	3	19	2	5	4	0.74

Questions B 4.1 & 2 Involvement of marketing and sales	mean	median	N	min	max	Biotech	Δ*
Our marketing / sales initiates innovation projects (IP)	3.03	3	31	1	5	3	-0.03
Marketing brings in customer perspective in IP	3.71	4	31	2	5	4	0.29
Marketing / sales has veto and can stop IP	2.87	3	31	1	5	2	-0.87
Marketing and sales is integrated in all phases of IP	3.58	4	31	2	5	4	0.42
Feedback of (potential) customers is asked very early	3.58	4	31	2	5	2	-1.58
Market launch of innovations is already planned during development	3.39	4	31	1	5	4	0.61

Questions B 4.3.1 a Short term initiative in Open Innovation (OI)	mean EUR	median EUR	N	min EUR	max EUR	N° of adopters*	Biotech EUR	Δ* EUR
Cooperation with Innovation agencies and intermediaries	29,032	12,500	31	0	375,000	20	250,000	220.968
Involvement of focus groups	8,065	12,500	31	0	37,500	16	0	-8.065
Active scouting	12,097	12,500	31	0	75,000	20	100,000	87.903
Establishing and using of own user communities	7,661	0	31	0	75,000	10	0	-7.661
Utilization of lead user method	4,839	0	31	0	75,000	7	0	-4.839
Crowd sourcing and ideas competition	3,226	0	31	0	37,500	6	0	-3.226
Implementation of toolkits for user innovation	2,823	0	31	0	75,000	2	0	-2.823
Participation / organization of Hackathons	0	0	31	0	0	0	25,000	25.000

**3 organization did not use any of the long term OI activities*

Questions B 4.3.1 a Short term initiative in Open Innovation (OI)	mean	median
Cooperation with Innovation agencies and intermediaries	2.10	3.5
Involvement of focus groups	1.58	2.5
Active scouting	1.77	2.5
Establishing and using of own user communities	1.45	2.5
Utilization of lead user method	1.29	2.5
Crowd sourcing and ideas competition	1.23	2.5
Implementation of toolkits for user innovation	1.13	1.5
Participation / organization of Hackathons	1.00	1.5

Questions B 4.3.2 Long term OI activities with external partners	mean EUR	median EUR	N	min EUR	max EUR	N° of adopters*	Biotech EUR	Δ* EUR
Formal innovation project with customer	22,984	12,500	31	0	75,000	21	50,000	27.016
Formal innovation project with competitor	10,887	0	31	0	175,000	10	50,000	39.113
Formal innovation project with supplier	26,613	12,500	31	0	175,000	22	25,000	-1.613
Research project with Universities and research organization	62,500	12,500	31	0	375,000	24	500,000	437.500
Cooperation with start ups	58,065	0	31	0	750,000	11	50,000	-8.065

**2 organization did not use any of the long term OI activities*

Questions B 4.3.2 Long term OI activities with external partners	mean	median
Formal innovation project with customer	2.16	3.5
Formal innovation project with competitor	1.48	2.5
Formal innovation project with supplier	2.26	4
Research project with Universities and research organization	2.61	3.5
Cooperation with start ups	1.87	3

Questions B 2.3 and 2.4.1 - 4 Support of employee innovation potential	mean	median	N	min	max	Biotech	Δ
Labour turnover in %	6.9	6	35	0.08	20	10.53	3,63
Training / education in days	5.39	4	34	1	5	2.29	-3,1
Education in field of OI	2.62	3	34	1	5	2	-0,62
Information of employees on OI	3.5	4	34	0.2	25	3	-0,5

Questions B 5.1.1 & 2 Innovation success	mean	median	Biotech
Category 4: Revenues with products / services new to the market during last 3 years	7%	1%	10%
Category 3: Revenue with products / services improved during last 3 years	10%	5%	1%
Category 2: Revenues with new or improved products, which competitors already have	10%	7%	0%
Category 1: Revenues with products / services not changed during last 3 years	73%	80%	89%
Revenues with products developed with external partners	8.2%	0.5%	100%
Profit with products developed with external partners	8.30%	0.5%	100%

Table 12: Results of questionnaire OI activities of German peer group and the Biotech firm Furthermore R&D expenses, number of staff and the calculated total OI expenses per organization, the OI expenses per head and the number of OI activities applied in each of the organizations

Compa-nies	R&D expenses	N° staff	Revenue EUR	B_4.3.1 short 1	B_4.3.1 short 2	B_4.3.1 short 3	B_4.3.1 short 4	B_4.3.1 short 5	B_4.3.1 short 6	B_4.3.1 short 7	B_4.3.1 short 8	B_4.3.2 long 1	B_4.3.2 long 2	B_4.3.2 long 3	B_4.3.2 long 4	Expenses OI total	OI expenses per head	N° of OI
1	200,000	90	13,000,000	0	0	0	0	0	0	0	0	12,500	0	0	75,000	87,500	972	2
2	350,000	65	6,000,000	12,500	0	0	0	0	12,500	0	0	37,500	175,000	37,500	0	275,000	4,423	5
3	90,000	150	21,500,000	0	0	0	0	75,000	0	0	0	0	0	0	0	75,000	500	1
4	120,000	115	8,600,000	12,500	0	12,500	0	0	12,500	0	0	12,500	0	12,500	0	62,500	543	5
5	1,200,000	50	5,200,000	0	0	12,500	0	0	0	0	0	12,500	12,500	12,500	75,000	125,000	2,750	5
6	700,000	172	30,000,000	12,500	12,500	12,500	12,500	0	0	0	0	37,500	0	37,500	175,000	300,000	1,744	7
7	50,000	330	47,000,000	12,500	12,500	0	37,500	12,500	0	12,500	0	0	12,500	0	12,500	112,500	341	7
8	500,000	na	0	na	na	na	na	na	na	na	na	na	na	na	na	0	na	na
9	25,000	na	0	12,500	12,500	12,500	0	0	0	0	0	12,500	12,500	0	12,500	75,000	na	6
10	150,000	na	0	na	na	na	na	na	na	na	na	na	na	na	na	0	na	na
11	35,000	na	0	na	na	na	na	na	na	na	na	na	na	na	na	0	na	na
12	120,000	na	0	0	0	0	0	0	0	0	0	0	0	12,500	12,500	25,000	na	2
13	500,000	na	0	na	na	na	na	na	na	na	na	na	na	na	na	0	na	na
14	1,000,000	na	0	na	na	na	na	na	na	na	na	na	na	na	na	0	na	na
15	80,000	na	0	na	na	na	na	na	na	na	na	na	na	na	na	0	na	na
16	500,000	45	50,000,000	0	0	0	0	0	0	0	0	75,000	37,500	37,500	37,500	187,500	20,833	4
17	1,000,000	172	51,000,000	0	12,500	12,500	0	0	0	0	0	12,500	0	0	12,500	50,000	291	4
18	30,000	89	9,400,000	0	12,500	12,500	0	0	0	0	0	0	0	12,500	0	37,500	421	3
19	1,000,000	132	41,000,000	37,500	0	0	0	0	0	0	0	0	0	37,500	375,000	450,000	3,409	3

20	250,000	460	103,000,000	0	0	0	0	0	12,500	0	0	0	0	75,000	375,000	462,500	2,636	3
21	200,000	400	63,000,000	12,500	0	12,500	0	0	0	0	0	12,500	0	12,500	12,500	62,500	156	5
22	60,000	311	34,130,000	37,500	12,500	0	12,500	0	12,500	0	0	12,500	0	0	12,500	100,000	322	6
23	300,000	230	50,000,000	75,000	12,500	12,500	12,500	12,500	12,500	0	0	12,500	12,500	12,500	37,500	212,500	978	10
24	5,000,000	3409	446,000,000	37,500	37,500	12,500	0	0	0	0	0	75,000	37,500	12,500	12,500	225,000	66	7
25	5,000,000	1650	145,000,000	75,000	12,500	12,500	12,500	12,500	0	0	0	75,000	12,500	12,500	12,500	237,500	152	9
26		504	69,000,000	12,500	12,500	12,500	12,500	0	0	0	0	12,500	0	12,500	12,500	87,500	198	7
27	500,000	950	80,000,000	12,500	12,500	0	12,500	12,500	0	0	0	0	0	75,000	0	125,000	132	5
28	150,000	1698	189,200,000	12,500	12,500	12,500	12,500	12,500	37,500	75,000	0	37,500	0	75,000	12,500	300,000	221	10
29	15,000,000	615	130,000,000	75,000	12,500	12,500	0	12,500	0	0	0	0	0	175,000	175,000	462,500	772	6
30	400,000	760	120,000,000	12,500	0	12,500	0	0	0	0	0	0	0	12,500	12,500	50,000	66	4
31	3,000,000	11300	2,300,000,000	375,000	0	75,000	75,000	0	0	0	0	75,000	0	75,000	375,000	1,050,000	93	6
32	150,000	700	14,000,000	37,500	0	12,500	0	0	0	0	0	75,000	0	37,500	37,500	200,000	286	5
33	350,000	450	1,000,000	12,500	0	0	0	0	0	0	0	12,500	0	0	0	25,000	56	2
34	1,000,000	na	0	12,500	12,500	75,000	37,500	0	0	0	0	12,500	0	12,500	12,500	175,000	na	7
35	5,000,000	na	0	na	na	na	na	na	na	na	na	na	na	na	na	0	na	na
36	1,000,000	470	120,000,000	0	37,500	12,500	0	0	0	0	0	12,500	12,500	12,500	12,500	100,000	213	6
37	250,000	853	25,000,000	0	0	12,500	0	0	0	0	0	0	0	0	0	12,500	103	1
38	200,000	400	80,000,000	0	12,500	12,500	0	0	0	0	0	75,000	12,500	12,500	37,500	162,500	406	6
Biotech	10,700,000	846	189,360,000	175,000	0	75,000	0	0	0	0	12,500	37,500	37,500	12,500	750,000	1,100,000	1,345	6

na = no answer