Accessing a World of Distributed Innovation:

Firm-Makerspace Collaboration

Master's Thesis

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Abstract

As knowledge has become increasingly distributed, innovative solutions are often available outside the R&D labs of major firms. The potential for these firms to acquire and leverage external knowledge is therefore an important agenda in current management literature, as the pace of change in knowledge may exceed firms' ability to address external developments.

Individuals engage in shared knowledge creation through the internet, but are also moving these creative processes off-line in shared workshops called makerspaces. Novozymes, a biotechnology firm, has attempted to access these knowledge sharing processes by engaging with one such makerspace, namely BiologiGaragen, in open collaboration. The collaboration led to the creation of a prototype for an open software bioethanol sensor. An analysis of this collaboration was conducted in order to develop an understanding of the firm-makerspace collaboration process and define areas for further studies. Thus, this study examines how a large R&D-intensive firm can engage in open collaboration with makerspace communities, and how it can affect the firm's ability to alter its resource base in a dynamic capability perspective.

The process model of Interactive Coupled Open Innovation, a model combining Open and User Innovation perspectives on distributed innovation, served as a framework for analyzing the firm-makerspace collaboration. Related literature on managing Open Source Software and firm-hosted communities, along with literature on dynamic capabilities, were applied to the framework in order to establish initial propositions for investigation. Empirical research was conducted in the form of semi-structured interviews with Novozymes employees, makerspace participants and external experts. The qualitative data was analyzed and coded in an iterative process.

The analysis found support for several of the propositions but unexpected results led to amendments to the propositions and a revision of the initial framework.

Intrinsic motivation for engaging in firm-makerspace collaboration was found for makerspace participants and firm employees. Additionally, the former were motivated by social interaction, while the latter desired challenges not found in their daily work and for management to approval. Initial contributions from employees were found important in order to establish a relation. Furthermore, makerspace participants needed to be involved in the process of defining projects.

Dedicating employees to participate and contribute actively to the community was found conducive to sustaining collaboration, building trust and enabling employees to influence project work. Formal control was ceded by the firm as the collaboration was loosely governed to adapt to the characteristics of the makerspace. However, this led to issues of employees doubting the value of firm-makerspace collaboration.

Benefits from firm-makerspace collaboration could be realized by establishing new resource configurations through three modes of dynamic capability: 1) leveraging existing resources in new ways, through employees participating in projects in makerspaces 2) accessing external resources, including alternative innovation processes and the human capital of makerspaces and 3) creating new resources internally, through knowledge and experiences from firm-makerspace collaboration.

These findings together led to a revision of the initial framework, from a model of four consecutive stages to one of three dynamic and interdependent stages.

The contribution of this research is thus to provide explorative theoretical and empirical insights and propose a process model for firm-makerspace collaboration. Future research within this field is required to test and elaborate on the framework as a larger amount of empirical cases emerge over time.

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List of Abbreviations

OI: Open Innovation

UI: User Innovation

ICOI: Interactive Coupled Open Innovation

OSS: Open Source Software

NZ: Novozymes

BG: BiologiGaragen

DIY: Do-It-Yourself

R&D: Research and Development

IPR: Intellectual Property Rights

Important Terms

Makerspace participants: Individuals participating voluntarily in work at makerspaces in their free time.

Firm-makerspace collaboration: Collaboration between one or more firm employees and makerspace participants, where the collaborative work takes place in an autonomous makerspace. The employee participates in the work as part of his or her employment.

Firm-hosted communities: Communities established and sponsored by firms. External voluntary participants, often users, are invited/encouraged to develop and work on the firm’s technologies or products in the community.

1. Introduction

In the 21st century, the former knowledge monopolies of large corporations and academic institutes have been broken up (Chesbrough, 2003a). Instead, knowledge has become increasingly distributed, meaning small firms and even independent individuals have attained larger capacity for creating, accessing, and sharing knowledge than ever before. This evolution has rapidly accelerated with the advent of the internet and social media, to the point that it now presents a real paradigm shift and challenge for the innovation strategies of modern firms (Chesbrough & Bogers, 2014). Whereas innovations were traditionally conceived inside the research and development (R&D) departments of large firms (Chesbrough, 2003a), the ease of creating and transferring knowledge has given a whole new range of actors the ability to innovate and commercialize their innovation with venture capital backing (Chesbrough & Bogers, 2014). Thus, much knowledge relevant to the firm is created externally, making it virtually impossible for one firm to find and absorb everything that may turn into relevant innovation (Christensen, 2006). As a result, disruption has become a more common occurrence (Dougherty, et al., 2013), with competitive, game-changing solutions emerging from unanticipated sources, as a large R&D budget is no longer a prerogative for successful innovation (Chesbrough, 2003a; Anderson, 2012).

The Maker Movement perfectly embodies this contemporary trend of individuals having the power to create and share knowledge swiftly and efficiently through social networks (Hansted & Carlsen, 2015). It is not an organization, but rather communities of 'Makers' that are interconnected in a global network (Anderson, 2012). Built on the same foundations as the movement of Open Source Software (OSS), the Maker Movement empowers individuals through the internet to collaborate, share their creativity, projects and ideas to create products and services, for personal use or commercialization, in completely new ways (Dougherty, et al., 2013). This strong culture of sharing is the common denominator of maker communities (Anderson, 2012), which otherwise vary greatly in population and area of focus. The majority of Makers are participating in their free time, expect no financial remuneration for their work and help each other free of charge. Some are even opposed to the concept of profiting from the innovation, which they believe should be available to all, and are thus suspicious of firm involvement (Kostakis, et al., 2014).

While software has been the dominant focus in the first decade of the 21st century, the Maker

Movement has started to design and produce physical products in what has been labeled "The New Industrial Revolution" (Anderson, 2012:13-16). The disruptive threat of this movement is real, as it has spawned both cheap alternatives to expensive products, such as the e-NABLE 3-D printed prosthetic hand (e-NABLE, 2015), and revolutionizing technology such as the Oculus Rift, a virtual reality hardware, which has been acquired by Facebook for $2bn (Forbes, 2014).

The movement is being watched by managers and researchers alike, as this model of open science has considerable potential for innovation. Franzoni & Sauermann (2014) propose that this model allows access to large quantities of labor and to rare, specialized and diverse skills and knowledge. Furthermore, Makers openly disclose details of their projects, which makes them transparent, efficient and easy to contribute to or replicate (Franzoni & Sauermann, 2014): *"You put out a problem and everybody tries to answer it and only one person needs to be right as opposed to the more cathedral model of software development, for example, where everything needs to be right and everybody needs to be right every time. If you put those two models against each other in competition, guess which one is going to win every single time."* (Hansted & Carlsen, 2015:00:14:52).

As the Maker Movement has a need for production equipment for physical products (the 3-D printer being a very popular tool for this), shared workspaces called 'Makerspaces' have emerged (Van Holm, 2015:6). While varying in terms of members, organization and facilities, they share the common denominators of providing access to equipment, an open community and learning opportunities. While geographically separate, the makerspaces are linked together through online networks (Fox, 2014; Howard, et al., 2014), thus combining global reach with physical presence and social interaction.

However, while research on trends in the new era of distributed knowledge is abundant, including Open Innovation (Chesbrough, 2003a), User Innovation (von Hippel, 2005) and Firm-Hosted Communities (Jeppesen & Frederiksen, 2006), the way in which makerspaces can be approached by firms has, to our knowledge, received little attention. This is arguably related to the dearth of empirical cases of firm-makerspace collaborations. The Baessy project, however, is one such case, where a large and R&D intensive firm, Novozymes (NZ), collaborated with an existing Makerspace community, BiologiGaragen (BG), to initiate an open project, carried out within the makerspace. The result of this open collaboration was a sensor for measuring bioethanol during fermentation, that could be used by industrial biotech and homebrewers alike (BiologiGaragen, 2015d). The innovation was neither protected in any way, meaning NZ could not claim ownership or patent it, nor was it in an area of NZ' core operation. What is interesting about this case is the untraditional partnership, where two inherently different organizational logics came together to innovate.

1.1 Problem Statement

The innovative potential of the Maker Movement and the apparent research gap related to firm-makerspace collaborations, led us to ask the following research question: *"How can a large R&D-intensive firm engage in open collaboration with makerspace communities, and how can it affect the firm's ability to alter its resource base in a dynamic capability perspective?"*

This problem was decomposed into three sub-questions, which we explore in the following order:

1. How can firm employees and makerspace participants be motivated to engage in firm-makerspace collaboration?
2. How should firm-makerspace collaboration be organized and governed?
3. How can firm-makerspace collaboration affect the firm's ability to alter its resource base in a dynamic capability perspective?

1.2 Elaboration on Sub-questions

Sub-question 1: The sub-question is based on the premise that if firms wish to collaborate with makerspace participants, who are essentially volunteers, they must attempt to motivate this effort. We analyzed what could motivate makerspace participants to participate in open collaboration but also the motives of NZ' employees, to investigate whether these were aligned. Contemporary literature on motivation found in OSS communities, firm-hosted communities and makerspaces was applied in order to explore whether findings from this literature could be juxtaposed onto the new context of firm-makerspace collaboration. We also analyzed the behavior NZ elicited in order to motivate makerspace participants to engage in collaboration.

Here, we concluded that makerspace participants and NZ' employees are motivated by the same intrinsic factors, with a few being unique to each party, while extrinsic motivation was found to be negligible. Additionally, firms should actively participate from the outset to signal their intent to contribute to the community rather than leech effort from it.

Sub-question 2: The organization and governance of the collaboration process were analyzed in order to investigate how these mechanisms influenced motivation and the processes of innovation in the makerspace. Of interest here, were the means available to the firm to attempt to control or guide the process towards value creation, relevant to the firm, without impinging freedom, creativity and motivation.
We found NZ' loosely organized, non-contractual approach to be including and motivated contribution. Further, the high level of personal engagement from the NZ employee was conducive to trust building, but also served as a method for potentially influencing the process, to compensate for the lack of formal controls.

Sub-question 3: In order to explore potential outcomes of firm-makerspace collaboration, we took our point of departure in the firm's ability to respond to the increasing pace of change in technology and knowledge creation. We therefore took a dynamic capability perspective, to investigate whether the collaboration could help develop NZ' capability to alter its resource base in order to flourish in the face of change in contemporary and future demands.
We found that collaborating with the makerspace could enable NZ to achieve new resource configurations, which they would otherwise not have achieved. This was achieved through exerting several modes of dynamic capability.

All three parts are based on propositions developed through inferences from literature on adjacent areas and on a process model of open innovation developed by Piller & West (2014). Our findings required a revision of the initial framework, and we thus arrived at our own process model for firm-makerspace collaboration including a revised set of propositions. The propositions are exploratory in nature and call for more research on the topic with a wider array of cases in order to test the general applicability of our findings. We hope to lay the groundwork for a full elaboration of the subject – not just as an interesting phenomenon but as a potential new management practice.

1.3 Delimitation

As collaboration with makerspaces is an emerging phenomenon, with few empirical cases available, the potential area to explore is at the same time limited and vast in scope. It is limited in that we were able to focus on only one particular relation between one firm (NZ) and one makerspace (BG). Not only the characteristics of these organizations, but also the way in which collaboration was carried out, namely an open collaboration on makerspace premises with the firm yielding control, are unique to this paper and many different cases could emerge. Thus, the paper examines how one particular collaboration was carried out and the findings may be unique to the circumstances. Alternative modes of collaboration may arise, providing new cases to explore in the same area.

However, as the concept is yet unexplored in the literature we could have chosen many alternative perspectives. We delimit ourselves from taking an Intellectual Property Rights (IPR) centric approach, although analyzing how firms can protect innovation made in open collaboration is also an area that begs further exploration. Other ways to leverage the collaboration, such as a human resource perspective, stakeholder analysis, and knowledge diffusion could have been explored. Due to rapidly changing innovative contexts, catalyzed to some extent by the Maker Movement, we found the dynamic capability perspective to be most relevant, as it deals with how firms can address environmental changes by renewing their resource bases, including how they acquire and utilize knowledge. Furthermore, the analysis focused on benefits and challenges of open collaboration, rather than the economic costs, in order to establish how and why open collaboration could be established. We also refrained from analyzing the particularities of NZ' internal processes of knowledge integration or an analysis of the makerspace network, due to concerns over access to data.

The focus was, then, on how open collaboration with makerspaces could be initiated, maintained and what the possible outcomes could be, in order to encourage and enable further scientific discovery of the phenomenon.

1.4 Disposition

In chapter two, our research methodology is presented.

In chapter three we present a literature review, which elaborates on the recent radical changes in how knowledge is created and shared. Different perspectives of how to cope with the distributed nature of knowledge are presented and the research gap between these and the specifics of open collaboration between a firm and a makerspace is elaborated upon. Furthermore, the literature on the Maker Movement is reviewed in order to build an understanding of the movement.

The theoretical framework, through which the analysis is done, is then presented. Initial propositions are made in order to answer each sub-question.

Chapter four is our case description, which describes NZ, BG, and the Baessy project.

Chapter five presents the results of our qualitative data analysis along with figures showing the essential concepts and categories that emerged.

The analysis, presented in chapter six, is split into three sections – one for each sub-question. The implications of the findings are discussed in chapter seven, where we also provide a revised framework before discussing further implications, which can be used for future studies or as inspiration for managers.

We conclude upon the thesis in chapter eight.

2. Methodology

The aim of this section is to provide an overview of the research methodology adopted to test the propositions developed in our theoretical framework and hereby answer our research question. We try to illuminate how our choices about research philosophy, approach and design are interrelated and how they affect our choice of research method. We further discuss our empirical data before applying a critical perspective on our methodology.

2.1 Research Philosophy

Research philosophy relates to the development of knowledge and the nature of that knowledge, and is often made up of ontological and epistemological considerations (Saunders, et al., 2012). We believe that our research question does not unequivocally suggest a particular philosophy to be adopted and find it more important to apply the relevant conceptions and methods that have practical relevance.

We recognize that there are many possible interpretations of the world and the aim of our research is not to arrive at a definite truth. We find the phenomenon of firm-makerspace collaborations, as our research question seeks to address, as a complex phenomenon, and therefore it does not exist independently of actors. Our ontological viewpoint thus embraces 'subjectivism' (ibid:132). However, we still believe that in order to advance research on this, to our knowledge, understudied area, it is useful to develop some general propositions reflecting a fairly external view of reality. We therefore adopt some characteristics of 'positivism', traditionally associated with 'objectivism', as we develop propositions and test them (ibid:134-135). Although this seems contradictory, it is possible to use both objectivist and subjectivist lenses in the same research (ibid).

Thus, we neither adopt a pure philosophy of 'interpretivism' (ibid:137) or positivism, but find it possible and useful to adopt a mixture of positions in order to undertake our research and answer our research question. We seek to develop concepts to support action and thus focus on investigating how firm-makerspace collaborations work in practice. The research philosophy adopted in our research is thus aligned with that of 'pragmatism' (ibid:130). Pragmatist epistemology refutes a purely positivist approach because no theory can satisfy its demands of objectivity and falsify-ability. Pragmatism further refutes a purely interpretivistic approach, as the level of subjectivity means that virtually any theory could satisfy the demands for a subjective truth (Powell, 2001b). Instead pragmatism assesses theory around the criteria of a theory's capacity to solve problems. The aim of research is not to find an objective truth or reality, but to facilitate human problem-solving. Truth, thus, becomes a practical concern of people trying to advance in scientific discovery and cannot be determined once and for all (Powell, 2001b; Pansiri, 2005). A "true" proposition then, is one that facilitates fruitful paths of human discovery, a dynamic and unfolding process of meaning creation (Powell, 2001a; Powell, 2001b).

2.2 Research Approach

When researching a problem, which to our knowledge is underexplored in both theory and practice, we believed it would be infeasible to have a unidirectional relation between theory and practice as in the 'inductive' and 'deductive' approaches (Bryman & Bell, 2011:13). Rather, our research adopts an 'abductive' approach (Saunders, et al., 2012:144) – moving back and forth between data and theory, in order to continually adapt our framework. Thus, we would be able to make inferences and ask new questions as our understanding of the concepts evolved. This was done for pragmatic reasons (ibid), as the nature of our subject required flexibility in our approach to account for emerging discoveries and constraints that arise.

The approach was vindicated in our research. After our initial meetings with NZ, we generated propositions based on our understanding of the collaboration and the limited theory of the subject. As our understanding evolved through analyzing data, we went back to the framework and made modifications to the stages of the process model, before eventually arriving at a cyclical model of three interdependent stages, rather than the initial, chronological four-stage model.

2.3 Research Design

In line with the reasoning for taking an abductive approach, we decided that research with an 'exploratory' purpose (Saunders, et al., 2012:171) would be interesting in order to begin filling the research gap. Our goal was to define the problem more precisely and establish propositions based on a review of the extant literature and refine them by supplementing with an analysis of empirical data.

In the following, our choice of methodology for gathering data to perform the explorative research is presented, followed by an overview of the data and how it was used to answer our research questions.

2.3.1 Research Method

The qualitative method of data collection was chosen in order to maintain our ability to adapt to and explore emergent and unanticipated themes. Quantitative data will often offer pre-designed response sets (Sreejesh, et al., 2014), where qualitative allows us to capture what is relevant to our respondents and change direction to pursue new topics (Saunders, et al., 2012).

With the limited amount of empirical cases available, and a desire to delve deeply into the complex topic through attaining many perspectives on a single subject, we focused on one particular case of firm-makerspace collaboration, namely the Baessy project. This 'idiographic' method of research design focuses on the unique features of a complex situation, through performing a rich and detailed analysis (Bryman & Bell, 2011:60). We included an 'instrumental' aspect to the case study in order to develop an understanding of the general issue of firm-makerspace collaboration. Case studies are often approached abductively and favor qualitative research, especially semi-structured interviews (ibid:63), which fits well with our approach and design.

We chose semi-structured interviews to gather data on the case, as they would provide us the freedom to pursue knowledge and themes emerging during the interviews (ibid:467), which is beneficial for explorative studies (Saunders, et al., 2012). Our questions were used as talking points and ways to keep the conversation going, rather than as means to focus on pre-defined issues. As our understanding of the subject evolved over time, so did the questions we prepared for each session, in accordance with the abductive approach. Interview guides are attached in appendix 3. We allowed interviewees to steer the conversation and provide new insights we would otherwise not have found. Some of our interviews even had similarities to 'unstructured interviews' (Sreejesh, et al., 2014:48).

For the qualitative data analysis, we used a process, which incorporated aspects of 'Grounded Theory' (Bryman & Bell, 2011:580). The method captures complexity, links findings to practice, is useful for open-ended research in under-researched areas (ibid), and involves moving back and forth between induction and deduction (Saunders, et al., 2012). With our research question as point of departure, we collected data based on 'theoretical sampling' (ibid:186) of interviewees we initially found relevant in relation to existing theory, but also those to whom we deemed access important based on our continuous interpreting of data. We transcribed our interviews for internal use and qualitative data analysis[1].

[1] The transcripts are not provided as many interviewees described personal relationships that they did not wish to be available in a searchable format, but recording of the conversations was agreeable to them. Thus we have attached the recorded interviews as sound files.

After the first round of interviews, we suggested initial propositions based on our empirical data and literature review. Over the next three rounds of interviews, we returned to our propositions and framework, in order to evolve our understanding and relate it to theory, by constantly comparing the 'concepts' that emerged from the coding process, and grouping the concepts into 'categories' (ibid: 577-578). Particularly propositions regarding how the firm could leverage the collaboration went through several iterations, as this was the area of greatest uncertainty and least representation in the literature.

In line with qualitative coding practice (Bryman & Bell, 2011), we continually reviewed the concepts in order to merge similar concepts and relate them to the utilized literature. Towards the end of our research, we revisited all our interviews to ensure the data were fully coded into the concepts and categories that had emerged during data collection. We then tested our propositions through an empirical analysis. Useful concepts are often found frequently (ibid:578). We therefore quantified the amount of times each concept appeared in the data, to identify tendencies. However, we also delved into the literal text of our interviews in order to retain focus on context, as coding eventually fragments data (ibid:588).

This process fit well into our desire for an exploratory study, the use of qualitative methods, and remaining open through an iterative approach. We arrived at a revised framework with accompanying propositions, built upon relevant literature and our analysis. This 'substantive theory' (Saunders, et al., 2012:50) is particular to our case, but represent a first step in understanding the subject in a wider context, as further studies can be made in different settings.

2.3.2 Empirical Data

To answer our research question, we needed to include both primary and secondary sources of data, in order to develop a comprehensive understanding of the phenomenon under study. Prior to conducting our main primary research, we had an explorative brainstorming session with three employees at NZ, who had responsibilities regarding open innovation and makerspace collaborations. This session helped develop our understanding of their central challenges and issues and worked as inspiration to develop ideas for further exploration. We also visited Labitat and BG several times to talk to the people in the makerspace and get a first-hand impression of how the space works.

2.3.2.1 Primary Data

We conducted four rounds of interviews from May to August 2015. While the shortest interview lasted 40 minutes and the longest two hours, the majority of the interviews had a duration of around one hour. From NZ, we sought to interview a diverse group of employees from both business development and R&D, in order to gather opinions from different departments of the firm. In addition we interviewed both managers, science managers and researchers. This was important to answer our sub-questions, since attitudes could potentially differ significantly between business developers, managers and the researchers closest to the R&D activities. Ten interviews were conducted with NZ employees, and we wanted to interview an equal number of makerspace participants. Unfortunately, it was only possible to conduct five interviews with makerspace participants. However, these individuals were central figures in the community, some even co-founders, with solid experience from being part of both Labitat and BG. Hence, they provided valuable and knowledgeable insights, which is important for exploratory research, where interviews often rely on the quality of the contributions from interviewees (Saunders, et al., 2012). Finally, we interviewed three individuals, which we term 'experts', to help shed light on the phenomenon of firm-makerspace collaborations from an external position. Indeed, interviewing experts is aligned with conducting exploratory research (ibid). Table 1 provides an overview of the 18 interviewees and the round in which they were interviewed.

Table 1 - Overview of interviewees

Novozymes Employees

Name	Initials	Position	Organization	Round of interviews 1	2	3	4
Frank Hatzack	FHAT	Head of Innovation Development	Business Innovation - Business Development	■			
Christian Brix Tillegreen	CBXT	Business Developer	Business Innovation - Business Development	■			
Gernot Abel	GEAB	Science Manager	Enzyme Assay Development - R&D	■			
Mette Frederiksen	MTFR	Senior Manager	Food - R&D		■		
Hans Peter Heldt-Hansen	HANS	Senior Manager	Food Applications, R&D		■		
Mikael Blom Sørensen	MKBS	Senior Manager	IP Strategy - HHC, R&D		■		
Fiona Becker	FIOD	Director	Food and Beverage - R&D			■	
Jens Eklöf,	JEEQ	Research Scientist	Food Applications - R&D			■	
Gitte Budolfsen	GIBU	Science Manager	Food Applications - R&D			■	
Ejner Bech Jensen	EJBJ	Vice President, Biotechnology Research	Biotechnology Research Management - R&D				■

External experts

Name	Initials	Position	Organization	1	2	3	4
Jakob Wested	JAWE	PhD fellow	University of Copenhagen, Faculty of Law	■			
Allan Alfred Birkegaard	AABH	PhD researcher	Roskilde University		■		
Lasse Kristiansen	LAKR	Senior Manager	Internal Innovation - Deloitte				■

Makerspace participants

Name	Initials	Position and background	Organization	Round of Interviews 1	2	3	4
Martin Malthe Borch	MMBO	Management consultant *Background*: Civil engineer in Biotechnology	BiologiGaragen	■			
Emil Polny	EMPO	High school Teacher - *Background*: Master's degree in Human biology	BiologiGaragen		■		
Miriam Alistar	MIAL	Co-Founder of FUGT *Background*: PhD in Computer Science	BiologiGaragen		■		
Søren Sørensen	SSØR	Interaction and Electronic Sketching intern *Background*: Bachelor in Digital Media & Design	Labitat				■
Niklas Nisbeth	NNIS	Programmer *Background*: Humanistic university degree	Labitat				■

2.3.2.2 Secondary Data

To advance our understanding of our research subject and to support our primary data, we included secondary sources of research. First, a thorough literature review of perspectives on distributed innovation, OSS, firm-hosted communities and the Maker Movement, helped guide us in developing our theoretical framework as well as designing interview guides. Second, empirical research on motivation in hackerspaces (Moilanen, 2012), the Maker Movement (Hagel, 2015a; Hagel, 2015b; Dougherty, et al., 2013) and a documentary on open collaboration (Hansted & Carlsen, 2015), contributed by broadening the perspective on our research subject and by backing up or contesting our findings. This served to 'triangulate' (Saunders, et al., 2012:318) our findings. Third, annual reports of NZ were used to investigate certain characteristics of the firm. Finally, articles and websites helped describe the course of an otherwise unstructured collaborative project, that made up our empirical case; the Baessy project.

2.4 Critical Perspectives on Methodology

2.4.1 Reliability

Ensuring replicability of our study, namely 'external reliability' (Bryman & Bell, 2011:395), is a difficult issue when using semi-structured interviews, as social settings will change over time and responses reflect what interviewees find true at that moment in time (Saunders, et al., 2012). In order to reduce 'participant error' and 'participant bias' (ibid:192) we held 15 out of 18 interviews in quiet, controlled surroundings and agreed with participants that they would have full discretion to ask for anything they said left out of the paper or to participate anonymously. Interviews concerned both retrospective and prospective topics, as well as personal opinions, which made it difficult to fully mitigate participant bias. More specifically, when talking about the openness of makerspaces, makerspace participants may be affected by their own idealism and positive associations to values of the Maker Movement. Similarly employees with positive experiences with makerspace collaborations, may be more inclined to make optimistic and positive statements about potential benefits. Finally, when asked about motivation, both NZ employees and makerspace participants may be hesitant to express a desire for pecuniary rewards as it may be taboo.

Our preconceptions of the phenomenon may affect how we ask questions and how we interpret the outcomes, which constitute 'researcher bias' (ibid:192). The iterative approach to both theorizing and gathering data meant that our understanding changed immensely from the first to the last interview. This allowed us to change our questions during the process and revisit older interviews with new perspectives, which is an advantage in terms of understanding, but makes the process difficult to replicate. Thus, we have attempted to outline our methodology in as clear and transparent terms as possible to allow for a degree of replication. In sum, reliability of our qualitative data is a complex issue. The inherent flexibility in the iterative process is difficult to re-create (ibid), but we have attempted to minimize factors in our process that could compromise reliability.

2.4.2 Validity

'Internal validity' of semi-structured interview is generally considered highly achievable, if the interviews are conducted thoughtfully (Saunders, et al., 2012:384). We took great care to clarify questions and search for deeper meanings and full expositions in our interviews in order to uphold congruence between our perception of the subject and the data. This is important in order to uphold internal validity (Bryman & Bell, 2011). Our goal of transparency, as mentioned under reliability, was also to make our research 'credible' (ibid:395), so others can evaluate the quality of our research practice. Furthermore, we submitted our findings to our interviewees before submission to allow for 'respondent validation' (ibid:396). Thus, interviewees could review the findings and validate that we had understood their perceptions correctly.

'External validity' concerns the generalizability of the research (Saunders, et al., 2012:194). With only one case being used, generalizability was not the main goal of our explorative research. However, a large amount of respondents in a single case can encompass many small settings (ibid:383). Thus, we attempted to collect data from respondents with many different perspectives, particularly in NZ where we reached a broad spectrum of employees, in different positions. Another argument related to the generalizability of qualitative research, is that relating research to existing theory serves as an argument for a wider theoretical applicability, than solely the specific case under study (ibid). Therefore, we sought to establish a strong relation to the used theory through rigorous immersion in the literature and an iterative process of data collection and analysis. Thus, our results could have broader significance, as they are linked closely with the theoretical foundation. In conclusion, our theoretical propositions and revised framework provide ample opportunity for further testing in different contexts and can facilitate future scientific discovery.

2.4.3 Limitations

The data sample of the study is relatively small, particular for makerspace participants of which we had five interviewees, which is arguably insufficient to capture the heterogeneity in makerspaces. However, our main goal was not to generalize about the population, but rather *"to theory"* (Saunders, et al., 2012:283), and we did gain access to those who had been involved in the particular project along with a few peripheral figures. While we had achieved respectable 'theoretical saturation' (Bryman & Bell, 2011:443) by the end of our interviewing, it may be because our respondents shared similar traits due to our sampling method. Had we interviewed more makerspace participants, we might have found individuals with a wider range of opinions.

Additionally, the prospective elements of our study, specifically concerning future outcomes of firm-makerspace collaborations, mean that our data and theorizing about how firms can leverage the collaboration, while theoretically founded, carries a degree of speculation. Furthermore, we had preconceived notions that engagement with communities can be leveraged, as is reflected in our research question, which means the study cannot be free from bias. However, as we present propositions that allow for future studies and have current practical applicability, the findings are useful although they may not encompass the full picture.

We used solely one qualitative method of gathering and analyzing data, which inhibited our ability to 'triangulate' (Saunders, et al., 2012:179) with other primary data. Though we did count frequency of our concepts, it was in an effort to identify overarching themes and determine "*usefulness*" (Bryman & Bell, 2011:578) of our concepts, rather than a quantitative approach of asserting significance to differences and similarities. Quantitative questionnaires are recommended for case studies (Saunders, et al., 2012), but we deemed them infeasible, as many of the topics of our research were context embedded and it would be difficult to ensure the meaning of questions was transferred correctly to respondents.

Finally, as we could not find research based on empirical cases of firm-makerspace collaborations, we had to look into similar contexts including OSS and firm-hosted communities and develop our propositions based on these findings and test them in the context of firm-makerspace collaboration. Thus, our approach will be affected by findings in these to analogous contexts, and therefore may direct us towards certain areas, which may leave other important areas in the context of firm-makerspace collaboration undiscovered.

3. Literature Review & Theoretical Framework

3.1. Innovation Models

The means and process through which innovation is made has experienced a paradigm shift during the early 2000's (Chesbrough, 2003a), although the roots of this shift could be argued to trace back well into the 1990's (Chesbrough, 2003a; Christensen, 2006). As the context in which firms innovated evolved from one of knowledge monopolies into a world where advanced knowledge is widely dispersed, so have the parameters for successful innovation changed.

The new paradigm of distributed innovation has been widely accepted by both academia and industry, but research has developed into two distinct streams, namely von Hippel's 'User Innovation' (UI), which focuses on individuals innovating to solve their own needs, and Chesbrough's 'Open Innovation' (OI), which focuses on firms leveraging knowledge flows (Bogers & West, 2012:61; Piller & West, 2014:29). The two streams differ on a range of issues, because they take different points of departure and thus end up with differing prescriptions. Indeed, they can be seen as models on two ends of a continuum, with a wide range of different models in between that draw upon a mix of aspects from either. Rather than attempt to unify the theories or use only one perspective, which can take away richness from the analysis (Bogers & West, 2012:71), we will draw upon both in order to capture the intricacies of our case.

In an effort to arrive at a definition and perspective suited to analyzing the innovation context explored in this paper, a review of the current literature on OI and UI will be performed. Piller & West's (2014) process model of 'Interactive Coupled Open Innovation' (ICOI) will then be presented, as it draws upon teachings from both perspectives in order to build a framework through which to analyze collaborations between firms and individuals or communities. First, however, the previous paradigm of Closed Innovation will be presented, in order to set the context for the current state of distributed innovation. This current state will then be reviewed through the literature of OI, which is then contrasted by UI.

3.1.1. The Closed Innovation Paradigm

For most of the 20th century, industry R&D labs generated most of the industrial research, as specialized knowledge and the means to pursue it was not available in the external environment

(Chesbrough, 2003a). In the closed innovation paradigm, discovery of new technology happened inside the firm and the first to make a development would bring it to market as the intellectual property could be protected from competitors (ibid). Innovation was achieved by hiring the best people and equipping them with necessary funds and equipment. The firm could then use the money earned from commercializing the invented technology to provide more funds for innovation, making this process self-reinforcing (ibid).

Thus, internal R&D became a prerogative for earning profits and a barrier to entry for new competitors. Corporations integrated vertically to not rely on inferior external suppliers (ibid).

3.1.1.1. The Downfall of the Closed Innovation Paradigm.

Chesbrough (2003a) originally proposed four factors that have led to the erosion of the closed innovation paradigm: the increasing availability and mobility of skilled workers, a large and growing pool of venture capital, external options for researched ideas not yet taken into development and the increasing capability of external suppliers. These factors meant that not only was more knowledge available outside of the large firms, but there was also a significant threat of unused technologies leaking outside of the inventing firm, as employees could find the necessary money and support to bring a product to market. Another erosion factor, namely the internet, and with it social media, was added by Chesbrough & Bogers (2014), as instant communication of opinion and data further compounds the distribution of knowledge.

3.1.2. Open Innovation (OI)

With knowledge being more readily available due to increased generation and ease of transfer, the supposed best practice of managing knowledge has shifted. In the new paradigm of OI, more knowledge is available outside the firm, external R&D can create value, and anyone can profit from research. The correct business model is more important than being first to market. *"Winning"* is making the most out of ideas created internally as well as externally, but also profiting from selling internally developed IP (Chesbrough, 2003a:xxvi).

The definition of OI is a contested space both in terms of what it covers, how to conduct it, and what the benefits are (Chesbrough & Bogers, 2014). Chesbrough (2006:1) proposed a refined definition of OI as *"the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and* *expand the markets for external use of innovation, respectively."* The flows being declared purposive is important, as it signifies intentionality from the firm and means these flows are not random spillovers but controlled occurrences. In closed innovation, spillovers were a weakness to the innovation model, while for OI they present new opportunities (Chesbrough, 2006; Chesbrough & Bogers, 2014). Further refinement of the definition is brought forth by Dahlander & Gann (2010). They proposed that not only do firms vary in their degree of openness, but the method of employing OI varies both in terms of direction (inbound vs. outbound) and compensation (pecuniary vs. non-pecuniary). Thus, value creation through OI does not necessarily have to stem from firms buying or selling technology, but can also involve indirect benefits such as creating standards, fostering incremental innovation, and leveraging external know-how to improve firms' own innovation and processes (ibid:703-706). Gassmann & Enkel (2004:12) proposes a third perspective on OI, namely 'Coupled Open Innovation'. This term represents firms utilizing both in- and outflows through strategic alliances with other firms either vertically, horizontally or both.

Synthesizing the above, Chesbrough & Bogers (2014:17) define OI as *"a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organizational business model."*. Of importance here is that the locus of innovation is placed within the firm, meaning that while information does flow in and out of the firm, the process of innovation still takes place inside the organizational boundaries and not in an open space (Chesbrough & Bogers, 2014; Gasmann & Enkel 2004).

3.1.2.1. Pros and Cons of Openness

Strong support for the benefits of accessing a deep and wide array of external channels has been found by Laursen & Salter (2006). Technical and social distance from the field of a given problem have also been shown to be predictors of innovation performance (Jeppesen & Lakhani, 2010), indicating that useful knowledge is available, and even more abundant, far from the regular social and professional circles of firm scientists. The spread of OI practices such as crowdsourcing (Afuah & Tucci, 2012) and pyramiding (Poetz & Prügl, 2010) indicates that managers recognize that valuable knowledge is located outside of the firm.

Chesbrough argues, that OI also serves to recover 'false negatives' – invented technologies initially found worthless can be picked up and made valuable by others (Chesbrough, 2003a:xxv). Thus, technologies and patents can be leveraged in new ways through management at the strategic level (ibid:57).

With so much information available externally, and thus an incredibly large opportunity set for innovation, finding the best ideas to pursue is also presented as a difficulty. Thus, there is proposed to be an upper limit to how open a firm should be, as 'timing-', 'attention allocation-' and 'absorptive capacity problems' begin to set in (Laursen & Salter, 2006:135). The optimal amount of external sources, then, varies across different innovation contexts (ibid:147).

Finally, Dahlander & Gann introduce specific costs to participating in OI, namely the costs of coordination and competition (Dahlander & Gann, 2010). Coordination costs include bridging disparate institutional logics across organizations, while competition costs stem from the risk of opportunistic behavior and protecting ideas.

3.1.2.2. A New Role for Internal R&D

Despite knowledge being available outside the firm, internal R&D should still be pursued, albeit under different conditions and new goals (Chesbrough, 2003a). Internal R&D remains a tool to *"fill in the missing pieces of knowledge"* (ibid: 53) unavailable in the public space, but new functions include scanning for useful external knowledge and innovating by combining it with internal knowledge.

This is reflected in the term 'Absorptive Capacity', which is the *"[…] ability to recognize the value of new information, assimilate it, and apply it to commercial ends."* (Cohen & Levinthal, 1990:128). However, since absorptive capacity generated as a spillover from R&D only applies to related areas of knowledge, it will not help firms capture solutions from completely different fields (ibid:150). With the accumulated global knowledge pool continually expanding, no firm can hope to achieve mastery of every relevant technology, but evidence suggests that firms are expanding their technological diversity, without diversifying their product line (Christensen, 2006). This appears to be an indication of firms recognizing the value of possible inputs from alternative fields and thus attempt to expand their ability to capture these.

3.1.3. User Innovation (UI)

OI researchers argue that while knowledge is widely distributed, the locus of innovation remained with the firm. Another stream of research dealing with the distributed nature of knowledge instead focuses on how innovation has been 'democratized' and is now in the hands of users (von Hippel, 2005:1). The perspective taken in UI is more individual centric and open than OI. It can be a difficult perspective to grasp for firms, as the main tenets of UI, namely free revealing rather than protection of innovation, a collective model of innovation rather than a private one, and non-pecuniary motives of innovation rather than pecuniary, are alien to many firms (Piller & West, 2014).

Von Hippel provides evidence of major innovation of commercially viable products being done particularly by 'Lead Users', who are characterized by being ahead of the curve in terms of needs and by high expected benefit from innovation (von Hippel, 2005:23). These products can be of high value and novelty (Lilien, et al., 2002:1055), especially when users are from analogous markets (Hienerth, et al., 2007) and/or exhibit strong lead user characteristics (Franke, et al., 2006).

An important distinction is that UI leads solely to specific outcomes of products and/or techniques (von Hippel, 2005), whereas the transfer of raw ideas is a major characteristic of the OI model (Chesbrough, 2003b). Furthermore, innovation is often shared freely within communities of users (von Hippel, 2005) or even to firms (Jeppesen & Frederiksen, 2006), instead of being protected as in the model of OI (Pisano & Teece, 2007). Thus, the potential for free-riding on the innovative efforts of others has been discussed, but Von Hippel & von Krogh's (2006:302-303) concept of the 'private-collective model for innovation incentives' posits that private benefit from innovations made publicly available are higher than the benefits of free riding. This is in part due to those actively involved in the process learning from it, but also due to knowledge being 'sticky' (von Hippel, 2005:67), meaning it cannot freely be transferred due to for example 'tacitness' of the information or lack of absorptive capacity of the receiver (ibid:68).

3.1.3.1 Communities of Innovators

The UI perspective has moved from an initially private model, where individuals worked on solely their own needs, to a collective model, where innovators share with the community and help each other's innovative efforts (Piller & West, 2014), a shift arguably spurred by the increased availability of the internet and social media. In these innovative communities, individuals collaborate on collective designs, intended for all to use and improve (Baldwin & von Hippel, 2011). The innovations are not made for the purpose of selling, but for all to have access to them.

There are many different versions of these communities and different ways of approaching or fostering them have been attempted by firms and captured in management literature of OSS projects (Baldwin & von Hippel, 2011; Dahlander & Magnusson, 2005) and firm-hosted communities (Jeppesen & Frederiksen, 2006; Ihl, et al., 2012).

While these models come close to describing the concept of collaborations between firms and makerspaces, there is still a need for a model, which specifically covers firms participating in user communities, rather than attempting to build communities around themselves, as the aforementioned practices do.

3.1.4. Interactive Coupled Open Innovation (ICOI)

While UI initially seems to be the perspective, which comes closest to capturing firm-makerspace collaboration, OI researchers have also begun to shift focus from *"dyadic interaction between two firms, to collaborations with external networks, ecosystems, and communities"* (West, et al., 2014:809). The impact of this shift on innovation practices in OI is, however, a relatively unexplored area (ibid).

In extension of this movement, Piller & West (2014) propose a new concept, ICOI, to capture *"collaborations where firms and individuals jointly create new knowledge or other inputs for an innovation process"* (Piller & West, 2014:36). ICOI builds upon the concepts of OI and UI, as each perspective is relevant but ultimately cannot fully capture the characteristics of such open collaboration. While the process is named after OI, it shares perhaps more similarities to the UI literature on communities of innovators.

Drawing upon Gassman's (2004) concept of Coupled OI, they open up for a refined version, fitting with an interaction form similar to firm-makerspace collaboration. In the ICOI process, the firm is working with individuals rather than other firms, and they are doing so in collaborative communities (Piller & West, 2014). Rather than the collaboration being controlled top-down, it is bottom-up, meaning individuals are the ones directing and implementing collaboration. Finally, the locus of innovation is outside the firm and *interactive*, meaning that the two collaborating parties are creating something new together, rather than sharing knowledge and then working on individual projects. This interactive locus of innovation differs from both OI and UI, as the former places the locus only inside the firm, while the latter leaves innovation exclusively to individuals (ibid).

While the definition is built on Gassman's (2004) concept of Coupled OI, it also draws upon many aspects of UI in order to emphasize the notion of firms participating in communities, rather than "hiring" them to work on firm products. Among the myriad of different perspectives found in the literature, then, the concept of ICOI best captures the phenomenon we seek to explore in our research. Piller & West (2014) present a process model for initiating, executing, and benefiting from ICOI. It consists of four stages: 'Defining', 'Finding participants', 'Collaborating', and 'Leveraging', each accompanied by key activities (Piller & West, 2014:40). This model may be the first step in bridging the research gap on firm-makerspace collaborations, although the authors have not directed the model towards specific types of collaborations. Moreover, there is lack of empirical founded research to elaborate upon and test this model. We thus believe to have identified a research gap which we seek to help fill. We apply the structure of Piller & West's (2014) model as a basis for our theoretical framework, which will be elaborated upon in section 3.3. We further develop propositions for each stage and then investigate these propositions empirically to contribute to the understanding of firm-makerspace collaborations.

3.2. The Maker Movement & Characteristics of Makerspaces

This section gives a short introduction to the Maker Movement and makerspaces by reviewing literature revolving around these topics.

3.2.1. The Maker Movement

The internet has democratized the tools of both invention and production. Any individual with an idea can develop and commercialize it without having to overcome high and costly barriers to entry (Anderson, 2012). These individuals who create and invent are Makers.

Projects shared online become inspiration for others and encourage collaboration. When individual Makers are globally connected they become a movement and suddenly millions of Makers start working and innovating together. This is happening not only with online services and digital products but also with physical products. A prominent example has been the introduction of the 3-D printer, which enables anyone to manufacture their own prototypes. The creativity and energy of entrepreneurs and innovators, collaborating and sharing their projects and ideas, can potentially reinvent manufacturing. The internet-generation has now turned to the physical world and this has been labelled as 'The New Industrial Revolution' (Anderson, 2012:13-16; Dougherty, et al., 2013:4).

The first signs of the Maker Movement came in 2005 with the launch of the Make magazine and the first 'Maker Faire' gatherings in Silicon Valley (Anderson, 2012:20). Although the Maker Movement is fairly young, it is accelerating at a rapid pace best illustrated by the growth of Maker Faires and total attendance (Figure 1). Maker Faire events are essentially gatherings of Makers and aspiring Makers, which build connections between these individuals and organizations. The number of events held around the globe has increased tremendously. It grew by 317% from 2011 to 2013 and total attendance has more than doubled from 241,000 to 530,000 people, as illustrated in Figure 1.

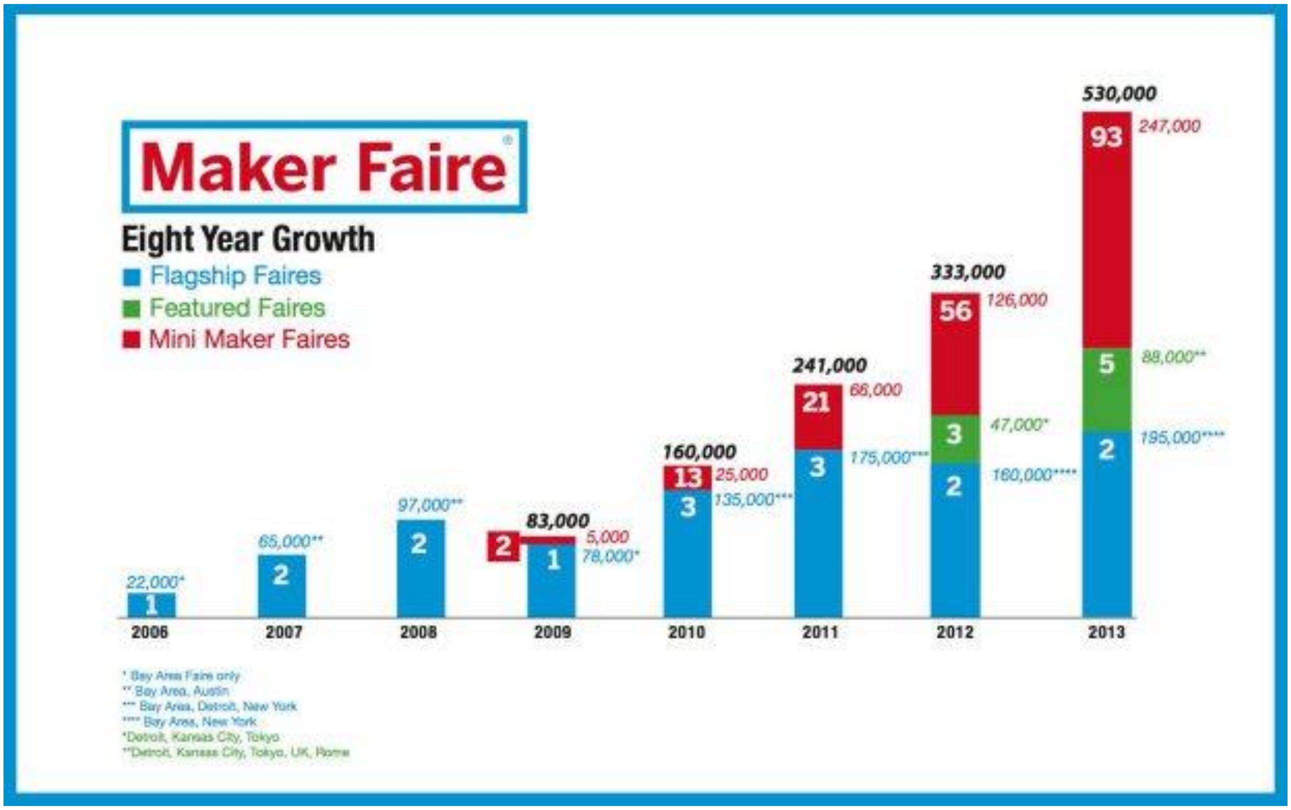

Figure 1 - Development of Maker Faires. Source: (Merlo, 2014)

The Maker Movement has been characterized as the emergence of the 21st century's industrial structure, which will be shaped by bottom-up innovation by countless individuals, including amateurs and professionals, rather than top-down innovation by the biggest firms in the world (Anderson, 2012; Dougherty, et al., 2013). This has potential to make up a serious disruptive threat to today's large firms (Dougherty, et al., 2013). In the Maker ecosystem, variations of products are explored, improved and disseminated faster than any individual or single firm could do (Anderson, 2012). Within the ecosystem *"[...] participants will combine and recombine as necessary to exchange skills, capital or learning, creating a resilient and agile network structure [...]. R&D effectively moves out of the corporate environment into niche development [...]"* (Dougherty, et al., 2013:5). Some large firms have already acknowledged the importance of collaborating with Makers (Anderson, 2012:20). As an example, General Electric has established GE Garages, which are fully equipped spaces connected to an online community, and encourages open innovation with participants to bring their ideas to life (GE, 2015).

3.2.2. Makerspaces & Hackerspaces

Shared production facilities, termed 'makerspaces', are growing rapidly. Although precise numbers are difficult to obtain, there are 1967 Hackerspaces (wiki.hackerspaces.org, 2015) and 412 Makerspaces (Makerspace.com, 2015) listed worldwide. Many makerspaces are created by local communities but there are also makerspaces being created by firms (Anderson, 2012).

Makerspaces are used as an overall term and can cover several types of communities (Van Holm, 2015). Simply put, makerspaces are open community centers with tools. They combine manufacturing equipment, community and education with the purpose to enable participants to design, prototype and create products. These spaces attract people, both professionals and amateurs, who share knowledge, time and effort on projects (Makerspace, u.d.; Van Holm, 2015; Thilmany, 2014; Howard, et al., 2014). Although Makerspaces are geographically separate, they are, as an inherent characteristic of the Maker Movement, digitally networked through blogs, forums, wikis and social websites (Fox, 2014; Howard, et al., 2014). Makers are taking the do-it-yourself (DIY) movement online, which brings network effects on a massive scale (Anderson, 2012).

Makerspaces are also known as Hackerspaces, because the concepts have converged towards a similar structure and use. Researchers have been divided on whether to view them as distinct or synonymously.

Studies have found that they are substantially similar, although there are some differences, as for example their origins (Van Holm, 2015).
For the purpose of this study Hackerspaces are treated as a specific type of Makerspaces, due to the strong similarities between the concepts (Anderson, 2012; Colegrove, 2013; Makerspace, u.d.; Thilmany, 2014; Van Holm, 2015). Makerspaces as a term is thus a continuum covering different types of communities, all with significant similarities outlined above.

The logics of these communities stand in contrast to most firms. Firms are generally characterized by bureaucracy, procedures and approval processes. Communities, however, are built on shared interests and needs and eschew formal processes as much as possible (Anderson, 2012). When anyone can contribute to projects and are judged not by their résumé, but on the merits of their ideas, some of the best contributors could be those working within other disciplines in their day job (ibid). Communities can freely take in participants, since they are not constrained by legal obligations, signing contracts and financial risks of choosing the wrong candidate, which are typically a part of a firm's hiring process (ibid). Communities thus tap into what has been described as 'The Long Tail of Talent', where skilled people self-select to work on projects they are passionate about regardless of their education and credentials (ibid:127-128). Finally, the mindsets of firms and communities differ, as makerspace participants are free to focus on the quality of the product without having to worry about the size of the market, which entails more freedom to innovate (ibid:78).

3.2.3. DIY Biology

The Do-it-yourself biology (DIYbio) community has emerged as part of the Maker Movement (Anderson, 2012). The first association in the field, DIYbio.org, was launched in 2008, and can be described as the pursuit of biology outside of scientific institutions by both professional experts and amateurs. It is evolving into a global movement by establishing global networks and websites and a general ethical framework for participants and laboratories across the world (Landrain, et al., 2013). "Biohackers" are establishing shared science workshops, in the category of Makerspaces, such as Biocurious in Silicon Valley, Genspace in New York City (Anderson, 2012) or BiologiGaragen in Copenhagen (Meyer, 2013).

Significant technological developments are happening in biology, as better tools and models are created for exploring and exploiting living systems. Especially within synthetic biology the development is extensive, as the aim is not only to understand but also to control processes in and around living cells. Engineers and biologists unite to design and build new bio-molecular components that can modify and reprogram livings organisms (Landrain, et al., 2013). As the biological technologies are becoming cheaper and easier to use, manipulate and control, it becomes possible to push the limits for what can be done outside large institutions and laboratories. More people can do more. The DIYbio community is proving that what was thought of as impossible, is now made possible with biotechnologies in the hands of students, inexperienced researchers and amateur scientists, such as biologists who practice biology as a hobby (ibid).

Biotech projects can be realized with only limited experience and access to equipment based on open-source biology (ibid). DIYbio is thus often praised for democratizing science, for the empowerment of ordinary people and for its educational, economic and socio-cultural value (Meyer, 2013). One concrete example of the modularization and standardization, is the development of the BioBrick toolbox, which allows development of prototypes of biological systems, without needing extensive R&D processes. Thus synthetic biology provides a growing number of people with the prerequisites to engineer biology with the potential to generate more novel and innovative ways to use biotechnology (Landrain, et al., 2013).

It should be noted however, that the focus of DIYbio spaces has been primarily on creating DIY versions of equipment and techniques already found in standard professional and academic labs (Anderson, 2012). However, it is by creatively designing and redesigning equipment and processes that they can give rise to new scientific practices (Landrain, et al., 2013). A telling example of this is Amplino: "*[…] a quantitative PCR diagnostic system that is open-source and much cheaper (less than $250) and easier to use than a conventional solution. Amplino can be used in developing countries as a diagnostic tool to detect malaria in less than 40 min. by using a single blood drop.*" (ibid:221) . This example shows, how disruptive technologies like Amplino are expected to fill an important niche for global health improvement (ibid). DIYbio makerspaces are indeed places of intellectual freedom that benefit from being open and include a diverse set of people, thus having the potential to rethink traditional biology by moving biotechnology out of the laboratory and into people's everyday lives (ibid:125)

Looking into the future, Anderson (2012) proposes that the new era is not the end of large firms, but it may be the end of the monopoly of large firms: "*What we will see is simply more. More innovation, in more places, from more people, focused on more narrow niches*" (Anderson, 2012:229)

3.3 Theoretical Framework

As described in the literature review this study focuses on the form of OI termed ICOI. Piller & West (2014) propose a process model for this form of OI between firms and external individuals or organizations. They propose that firm-initiated collaboration efforts has four major process stages, which are 1) Defining, 2) Finding participants, 3) Collaborating and 4) Leveraging, where each stage entails several key activities (Piller & West, 2014:40).

'Defining' entails the firm formulating the problem, they wish to solve, and the amount of resources they wish to commit to the effort, while paying close attention to the institutions and rules they will encounter in the community and in the wider societal context.
'Finding participants' entails identifying, motivating and selecting external partners with the right skills to solve the problem defined in stage one.
'Collaborating' entails interactive collaboration between the firm and individuals. How it is governed and organized facilitates this collaboration, but also the openness of the firm in terms of attitudes, processes and structure.
'Leveraging' entails how firms realize benefits from the interactive collaboration effort in terms of integrating knowledge or commercializing products and services. This is where the largest research gap appears in the literature, as little is known about the actual benefits of this type of collaboration (ibid:41).

In fact, there exists a research gap, to our knowledge, concerning the entire process, which collaborations between firms and makerspaces might go through. To answer the main research question, and the three sub-questions, the analysis will thus investigate firm-makerspace collaboration and how it fits with the four stages in Piller & West (2014)'s process model and use this as an overall structure. Based on a theoretical discussion on central themes around open communities, it will focus on specific activities of each stage. These are formulated as propositions in the following sections. Investigating the first two stages of the model (section 3.3.1), we will focus on motivation of individuals to participate, which we argue is an underlying factor of several key activities of these two stages (Piller & West, 2014). This concerns defining problems that are motivating and how to motivate both the allocated employees and the external collaborators to engage in collaboration. In studying the third stage (section 3.3.2), we will focus on the key activities of the firm's approach to organization and governance of the collaboration process (ibid). Finally, we will study the fourth stage (section 3.3.3) by focusing on realizing benefits from the collaboration (ibid:46) in a dynamic capability perspective.

3.3.1 'Defining' and 'Finding Participants'

3.3.1.1 Motivation of Makerspace Participants

Kostakis, et al. (2014) investigated to what extent hackerspaces share mechanisms for motivation, culture and governance with Commons-based online communities, such as OSS communities. Hackerspaces was used as a term for open communities where participants also share knowledge, ideas, tools and equipment in a physical space (Kostakis, et al., 2014). Thus, this definition is in accordance with our definition of Makerspaces engaging in both online and offline activities. Motivation of participants in hackerspaces has received little attention according to Kostakis, et al. (2014). The most cited work on the topic (Moilanen, 2012) has been cited 25 times, and it focuses as much on demographics as on motivation. Kostakis, et al. 2014 has been cited four times and none of these citations are made in attempts to validate or disprove the findings (Van Holm, 2015; Allen & Potts, 2015; Toupin, 2015; Şenalp & Şenalp, u.d.). Furthermore, Kostakis et al. (2014) exclusively use email in 16 out of 23 interviews. Accordingly, we find it relevant to further explore the topic of motivation.

Kostakis, et al. (2014) found that hackerspaces and online communities are very similar regarding their participants' motivational incentives, which they term 'intrinsic positive motivation'. Money was a peripheral factor only. The most important motivational factors were communication, face-to-face interaction, fun, learning, altruism and community commitment (Kostakis, et al., 2014).

Shah (2006) studied why individuals participate in innovation communities. They found that there were two types of participants, which had different motivational incentives in the open source community. Need-driven participants, a diverse group of people regarding skillsets and needs, were motivated to create new products to solve their own needs. Further, they were motivated to contribute to the community by reciprocity, feedback and discussions that could lead to future improvements, which in turn might be useful to themselves. Hobbyists, often highly experienced and skilled people, were motivated to create by fun and enjoyment and felt intrigued by finding solutions to problems. They were motivated to contribute by getting feedback, that their work was valued and useful to others. Thus, they show a social motivational factor similar to the findings of Kostakis et.al. (2014). In addition, hobbyists' motivation was affected negatively by high levels of control in the community (Shah, 2006). Again, extrinsic motivation was not often reported. Career concerns and reputation building were rarely mentioned as motivational factors (ibid).

Shah (2006) studied cases of online OSS communities, but as Kostakis et.al. (2014) found hackerspaces to be significantly similar, we find it reasonable to include the findings as a basis for research in our context.

Finally, Franzoni & Sauermann (2014) studied crowd-science projects related to biology. One of the cases studied was the Foldit crowd-science project within biochemistry, which enabled people to modify a visual 3D model of protein to optimize its shape without knowing anything about biochemistry. People participate in crowd-science projects voluntarily without being paid, because they are intrinsically motivated by enjoyment of an intellectual challenge, fun, personal interest, the opportunity to contribute to science and the feeling of accomplishment. In addition participants may enjoy being part of a community and derive social benefits from personal interactions (Franzoni & Sauermann, 2014).

The motivational factors found in all of the above studies were *primarily* intrinsic for all types of voluntary participants. We therefore propose that the same types of motivation will dominate in makerspaces and for individuals engaging in collaborative projects with firm employees:

Proposition 1.a: Makerspace participants will primarily be motivated to engage in collaboration by intrinsic motivational factors, such as enjoyment, learning, challenge, freedom and social interaction.

3.3.1.2 Motivation of Firm Employees

To our knowledge, little research has investigated the motivational factors of paid participants; employees who participate in open communities as part of the innovation strategy of their firm. However, in the study of Shah (2006), participants directly compare communities to their normal work environment, which gives us a starting point from which to explore the subject.

Shah (2006) found that hobbyists were motivated by the freedom and creativity they experienced when participating in the community, in contrast to the more structured and disciplined work environment of their firm (Shah, 2006). In addition, many reported that their normal work activity was not sufficiently interesting or engaging, which motivated them to pursue creativity and challenges in community projects (ibid). For the purpose of our research, we thus propose that employees are motivated to engage in collaboration in makerspaces by intrinsic motivational factors:

Proposition 1.b: Firm employees will be motivated to engage in collaboration in makerspaces by experiencing freedom and creativity as well as the challenge of working on interesting tasks not found in their daily work environment.

3.3.1.3 Preemptive Generosity

In setting out to discover, what a firm could do to incentivize individual users to 'push' their ideas into a firm-sponsored OSS project, Spaeth, et al. (2010:423) discovered four enabling contexts: 'preemptive generosity', 'continuous commitment', 'adaptive governance structure', and 'low entry barriers'. The relationship between low entry barriers and enabling contribution was not deemed as robust as the others (ibid:427) and related to lowering technical entry barriers for OSS protocols. Furthermore, non-technical barriers are discussed at the community level, rather than the project level, and are thus beyond the scope of this project. Thus, it is not included in the analysis.
Preemptive generosity will be discussed here since it revolves around motivating participants to engage in collaboration with the firm initially, which is part of stage two, finding participants, in the process model for ICOI (Piller & West, 2014). We will return to the two remaining contexts in section 3.3.2.

Preemptive generosity often takes the form of firms initially giving away source code (Spaeth, et al., 2010; Dahlander & Magnusson, 2005) or even patents, in a process of selective or, in radical cases, free revealing (West & Gallagher, 2006; Henkel, et al., 2014). The motivational benefit of this practice is supported by Dahlander & Piezunka's (2014) finding, that the positive effect of 'proactive attention' on eliciting outside suggestions is higher in the early stages of a project (Dahlander & Piezunka, 2014:819). Proactive attention entails that firms actively contribute with their own suggestions. However, anything the firm can provide, which the community deems beneficial, such as providing infrastructure or donating money/equipment (Dahlander & Magnusson, 2005), could fall into the category of preemptive generosity. However, it is important that makerspace participants feel these contributions are *"'without strings'"*, as many makerspaces are skeptical of firm involvement (Kostakis, et al., 2014) and are wary of firms exploiting them (Dahlander & Magnusson, 2005).

Proposition 1.c: Firms can motivate makerspace participants to engage in collaboration through preemptive generosity, as long as contributions carry no obligations for makerspace participants.

3.3.2 'Collaborating'

Having discussed what motivates individuals from firms and makerspaces to engage in firm-makerspace collaboration, we now delve into the actions a firm can take in order to organize and govern collaboration, which is part of stage three, 'Collaborating', in the process model for ICOI (Piller & West, 2014:40).

In the study of Spaeth et.al. (2010), mentioned in section 3.3.1, measures to motivate members to contribute freely are proposed, but one could contend whether contributions should be free or compensated for with pecuniary incentives. As we have discussed in the build-up to our previous propositions, money is not deemed a primary motivating factor in makerspaces. Even the logistics of setting up such remuneration schemes would be complex at best, with contributions varying in degree, frequency, and identifiability. Furthermore, financial incentives can create a 'competition effect', lowering trust and voluntary cooperation, as users focus on their own ideas instead of participating in the collective effort (Ihl, et al., 2012:11). Not only is this demotivating, or at least it changes the motivational dynamics from a 'community' to a 'market' context (Boudreau & Lakhani, 2009:5), but it also erodes the benefits of disclosing intermediate inputs, which is posited to be a significant advantage of collaborative innovation (Franzoni & Sauermann, 2014).

Thus, with the model of Spaeth, et al. (2010) as a starting point we delve into the enabling contexts of continuous commitment and adaptive governance.

3.3.2.1 Continuous Commitment

Continuous commitment can take form of sustained preemptive generosity (Spaeth, et al., 2010). Equally important, is to have firm employees continuously do actual work on projects and be physically present, as the worth of members of makerspaces is weighed by their contributions (Kostakis, et al., 2014) and work effort is based on norms of reciprocity (Shah, 2006). Furthermore, physical presence is paramount to building trust – a process which is crucial in open collaborations (Kostakis, et al., 2014). These ideas will be elaborated below.

Dahlander & Wallin (2006) studied individuals who work in communities as part of their employment, and how these individuals act in a community. The authors put forward the idea that a user community can be seen as a complementary asset, but firms will find it difficult to profit directly from the community, as the community has mechanisms against appropriation and cannot be directly controlled. Firms have to find a way to gain access to the knowledge and work in the community and indirectly convert it into a complementary asset. They can do this by deploying resources, in the form of employees, to participate in the communities. Even though competitors cannot be prevented from free-riding on the open collaborative effort, the focal firm can justify its own participation by achieving relational advantages from a position in the network (Dahlander & Wallin, 2006). The study found that firm employees are likely to develop more ties in the community network than voluntary participants. The authors thus propose, that firms must deploy employees to interact with other participants in the community, as it cannot be acquired as a complementary asset through the market but requires participation, interaction and learning (ibid).

As noted earlier, reciprocity is one of the key motivational factors driving participants' engagement (Shah, 2006), which supports the above idea of having employees actively participating in the communities. This is aligned with the 'symbiotic approach' to community relations (Dahlander & Magnusson, 2005:488). Using the symbiotic approach implies that the firm is focusing on the realization of mutual benefits, partly by devoting employees to contribute. In the 'commensalistic approach' the firm also devotes employees to work in the community, but with the goal of searching for useful input from the community rather than actively contributing to it (ibid). In this case only the firm gains, while the community is indifferent, thus possibly hurting participants' motivation to contribute.

Together, these findings suggests that having employees paying attention and actively contributing are key for fruitful interactions with open communities. We thus propose, that firms engaging in collaborations with makerspaces should adopt a similar mode for collaborating:

Proposition 2.a: Firms should maintain an interactive relation, by dedicating resources, in the form of employees, to actively participate in makerspaces in order to increase motivation and engagement from makerspace participants.

Studies have investigated the factors contributing to individuals being identified as leaders in open communities (Faraj, et al., 2015; Fleming & Waguespack, 2007; Dahlander & O'Mahony, 2011).

Fleming & Waguespack (2007) states that in order to understand the success of open communities, one has to understand the emergence of their leaders. Despite their flat organization and the informal, unplanned and sometimes chaotic appearance, open communities rely on strong leadership to function. In the context of open communities, that lack monetary incentives, hierarchical authority and formal structure, leadership depends more on trust and mobilization of peers than on approval from superiors (Fleming & Waguespack, 2007). Dahlander & O'Mahony (2011:962) emphasize 'lateral authority' as opposed to 'hierarchical authority' in communities. Lateral authority is defined as authority over collective work that does not include vertical authority over individuals. Individuals with lateral authority are at the center of projects, often having increased responsibility of coordinating collective work without supervising others (Dahlander & O'Mahony, 2011). In addition Faraj, et al. (2015:403) propose a structural approach to leadership and the concept of social capital, emphazising the importance of a leader's ties.

The above studies found that technical and knowledge contributions will increase the individual's likelihood of being identified as and becoming a community leader (Dahlander & O'Mahony, 2011; Faraj, et al., 2015; Fleming & Waguespack, 2007). In addition, engagement in coordination work will increase the likelihood of an individual to progress to positions of more lateral authority (Dahlander & O'Mahony, 2011). High levels of structural social capital also increases the likelihood of attaining leadership and furthermore reinforces the relationship between contribution and coordination and attaining leadership (Faraj, et al., 2015). Indeed, findings indicate that community boundary spanning increases a member's likelihood of becoming an open community leader (Dahlander & O'Mahony, 2011; Fleming & Waguespack, 2007). Especially communication and coordination, rather than technical contributions, across boundaries are found to be important (Dahlander & O'Mahony, 2011)

The above findings suggest that leadership in open communities is emergent and arises as a result of individual contributions. Leadership in itself is a way to influence and direct projects and agendas as well as mobilize participants. Thus, having employees actively participating, contributing and building relations in open communities may enable firms to influence the direction of development in these communities to some extent (Dahlander & Wallin, 2006). This is supported by the notion of subtle means of control that aim at influencing the community in a certain direction (Dahlander & Magnusson, 2005). Two important means are to devote employees to work in communities and to build and maintain reputation. By working in projects as peers, employees can keep track of progress and influence decisions, and skilled employees may achieve a strong reputation in the eyes of other participants. Employees who are well-known and respected will have a higher ability to influence the community activities, than employees who are less well-connected (ibid). Relating this to Proposition 2.a, firms taking a symbiotic approach therefore have better opportunities to apply subtle means of control (ibid), while not hurting participant motivation since the community gains at the same time.

Finally, the fundamental importance of trust in open communities could be especially important for employees. Other participants must believe that a leader's objectives and goals are in congruence with theirs or the community's and are not affected by commercial or political biases (Fleming & Waguespack, 2007). According to the findings of Enkel (2010), the perceived reliability and predictability of the partners' actions are key to build trust, which is a basic pre-condition of openness and reciprocity (Enkel, 2010). Employees working in makerspaces should thus participate on a regular basis to build trust.

Based on the discussion above, we propose that even though firms may not directly control collective work in makerspaces, there are possibilities to push agendas important to the firm by having employees gaining lateral authority in the community:

Proposition 2.b: Firm employees can build trust and gain influence by making strong technical, communication and coordination efforts, and thus increase the possibility for the firm to influence community work towards valuable agendas.

3.3.2.2 Adaptive Governance

Ceding control of the project and ensuring makerspace participants and employees are equals is an important part of enabling an 'adaptive governance' structure (Spaeth, et al., 2010:424). Although subtle means of control are needed to influence the direction of the collaboration, overt control stifles creativity and motivation, as it runs counter to the notions of freedom and lack of hierarchy in open communities (Dahlander & Magnusson, 2005; Shah, 2006; Kostakis, et al., 2014). Thus, it is important for firms to adapt to the desire for autonomy and for fair, consensus-oriented governance mechanisms (Spaeth, et al., 2010), they will inevitably encounter when collaborating with makerspaces.

O'Mahony (2007:144) proposes 'The Community Managed Model of OSS Development'. The model has five important features, and we will pursue three of these to discern whether they appear in the context of firm-makerspace collaboration and the extent of their value. In relation to the enabling contexts presented by Spaeth, et al. (2010: 424), we characterize three of these features ('independence', 'decentralized decision-making' and 'autonomous participation') as applicable adaptive governance issues. The other two features, 'Representation' and 'Pluralism', concern the governance and composition of large online communities, rather than individual projects (O'Mahony, 2007:147). We therefore consider it outside the scope of our research on firm-makerspace collaborations, as we are not analyzing how a firm can govern entire communities, but how to govern a collaborative project.

O'Mahony (2007) proposes that firms should ensure the 'Independence' of the project from overt firm control (ibid:144). Avoiding the use of contracts or other agreements, including decisions over who owns outcomes of collaboration and how much the individual parties are obliged to contribute, contributes to maintaining this independence. In collaborations where all individuals are on equal footing, there should be less risk of employees seizing control through their employment position, as they possess the same level of decision-making rights as other participants in the community (ibid:145).

Governance that does not allow for 'decentralized decision-making' (ibid:147) are likely to break with the tenets of makerspaces. As makerspace lack formal processes and structures (Section 3.2.2), decisions in makerspace projects are arguably made by the project participants, thus decentralized decision-making will often occur naturally. This model of decision-making, however, leaves the project vulnerable to moving in a direction that the firm may not benefit from. As such, it is important for the firm to participate in this process. Accordingly, employees must possess autonomy to make independent decisions (Foss, et al., 2011), which they deem beneficial to the firm, as only those close to the project can have the in-depth knowledge and the position from which to have influence.

'Autonomous participation' entails allowing participants to contribute on their own terms (O'Mahony, 2007:148). As contributors are invited to self-select for tasks, projects need to be made accessible both on technical and social parameters. A transparent, inclusive model of working that allows (prospective) members to contribute in various ways, locations or subprojects (ibid:146) could make projects accessible. Thus, the collaboration model must balance the need for getting specific input, with the flexibility that allows participants to contribute with exactly their knowledge and process of working.

Proposition 2.c Firm-makerspace collaboration should be characterized by adaptive governance that supports Independence, Decentralized decision-making and Autonomous participation.

3.3.3 'Leveraging'

To cope with environmental changes, firms need to renew themselves, which involves changing organizational resources and competencies over time (Danneels, 2010:1). Christensen (2006) argues that as innovative knowledge and technology develops rapidly outside of the firm, it must ensure that core competencies do not turn into core rigidities. Firms must therefore increasingly seek to develop 'integrative competencies' (Christensen, 2006:57). One key feature of these integrative competencies is the firm's 'dynamic capability'; the capacity for reconfiguring the firm's resource and knowledge base and building internal as well as external capabilities for addressing changing environments, which then becomes a key asset (ibid:58). The integrative competencies need to be responsive and adaptive to changing external factors and are not as strongly associated with specialized technological knowledge as core competencies are. This entails a more open approach than traditionally taken in large R&D intensive firms (ibid:46-47).

In an increasingly open innovation world, a central premise is that superior technological capabilities are increasingly being developed outside of the large firm. Technology entrepreneurs develop advanced technological knowledge, 'bodies of understanding', while large firms often provide the integrative and dynamic competencies, 'bodies of practice' (ibid:48). Building on Nelson (1998) and Pavitt (1998), Nesta & Dibiaggio (2003) makes the following distinction between bodies of practice and understanding: Bodies of understanding reflect the qualifications in specific technological fields or general domains of knowledge and are often related to fundamental disciplines, while bodies of practice are related to the selection and integration of different bodies of understanding, in the context of their application, and are thus context-specific knowledge (Nesta & Dibiaggio, 2003).

From an innovative asset perspective, large firms will then have to *"[…] look out for external (as well as internal) innovative ideas, new technologies, concepts or IPs to align with and integrate into new or improved product architectures.*" (Christensen, 2006:48), and from an operational asset perspective "*[…] to look out for external (and internal) innovations in search of, and sometimes in exchange for, complementary assets*" (ibid). Since the makerspaces and their networks rapidly create new ideas, innovative knowledge and technological capabilities (Anderson, 2012), they are relevant places to search for innovations.

The notion of integrative competencies and dynamic capabilities then becomes highly relevant for firms looking to engage in collaboration with makerspaces.

Dynamic capability broadly refers to the firm's ability to renew its resource base to address environmental changes (Teece, et al., 1997; Eisenhardt & Martin, 2000). Building on Eisenhardt and Martin (2000), Danneels (2010) describes four modes of how a firm can alter its resource base; 1) leveraging existing resources, 2) accessing new resources externally, 3) creating new resources and 4) releasing existing resources. In addition, a new element of dynamic capabilities is introduced, called 'resource cognition', which refers to managers' mental models of the firm's resources and understanding of possibilities for application (Danneels, 2010:3). Resource cognition therefore influences how dynamic capability is exerted, and thus becomes relevant to include in the analysis.

The evolution of dynamic capabilities are guided by certain learning mechanisms, which are: repeated practice, codification of experiences into technology and formal procedures, making mistakes and a steady pace of new experiences over time (Eisenhardt & Martin, 2000). Thus, by exerting dynamic capability, the capability itself is at the same time developed, through accumulated experience.

Firms with a higher dynamic capability thrive in the face of environmental changes because they have the ability to change their resources (Teece, et al., 1997; Eisenhardt & Martin, 2000; Danneels, 2010).

The above concepts combined, thus leads us to propose, that firms engaging in collaborations with makerspaces are able to purposefully build and combine new knowledge, competencies and resources, making them better prepared to address environmental changes:

Proposition 3: Firms can improve their dynamic capabilities through firm-makerspace collaboration by leveraging existing resources in new ways, accessing new resources externally, creating new resources and releasing resources.

3.3.4 Overview of Theoretical Framework

We have integrated the stages of Piller & West's (2014) process model for ICOI, our sub-questions and the related propositions in our theoretical framework, which is summarized below in Table 2.

Table 2 – Theoretical framework - Firm-makerspace collaboration

Stage	Sub-question	Propositions
1. Defining 2. Finding Participants	Sub-question 1: How can firm employees and makerspace participants be motivated to engage in firm-makerspace collaboration?	Proposition 1.a: Makerspace participants will primarily be motivated to engage in collaboration by intrinsic motivational factors, such as enjoyment, learning, challenge, freedom and social interaction. Proposition 1.b: Firm employees will be motivated to engage in collaboration in makerspaces by experiencing freedom and creativity as well as the challenge of working on interesting tasks not found in their daily work environment. Proposition 1.c: Firms can motivate makerspace participants to engage in collaboration through preemptive generosity, as long as contributions carry no obligations for makerspace participants.
3. Collaborating	Sub-question 2: How should firm-makerspace collaboration be organized and governed?	Proposition 2.a: Firms should maintain an interactive relation, by dedicating resources, in the form of employees, to actively participate in makerspaces in order to increase motivation and engagement from makerspace participants. Proposition 2.b: Firm employees can build trust and gain influence by making strong technical, communication and coordination efforts, and thus increase the possibility for the firm to influence community work towards valuable agendas. Proposition 2.c Firm-makerspace collaboration should be characterized by adaptive governance that supports Independence, Decentralized decision-making and Autonomous participation
4. Leveraging	Sub-question 3: How can firm-makerspace collaboration affect the firm's ability to alter its resource base in a dynamic capability perspective?	Proposition 3: Firms can improve their dynamic capabilities through firm-makerspace collaboration by leveraging existing resources in new ways, accessing new resources externally, creating new resources and releasing resources.

4. Case Description

This section gives a short description of the empirical case that will be analyzed. The first section gives an introduction to NZ, the second section gives an introduction to BG and the third section describes their collaborative project.

4.1 Novozymes A/S (NZ)

NZ is a biotechnology firm with more than 6,400 employees on six continents (Novozymes, 2014). NZ is a business-to-business firm producing a broad range of industrial enzymes and microorganisms and selling to a broad range of industries including household care, food & beverages, bioenergy, agriculture & feed and technical & pharma (Novozymes, 2014). They have a strong focus on enzymes and are the world's leading producer of industrial enzymes with an estimated market share of 48% of the global market (Novozymes, 2014). Sustainability is at the core of the business, as they seek to help address the challenge of the world's increasing consumption and strain on natural resources. Their biological solutions are used to improve efficiency of industrial production processes by using less raw materials, such as water and energy, while reducing waste (Novozymes, 2014).

NZ is an R&D intensive firm. Over 20% of the workforce is working in R&D and around 14% of sales are invested in R&D annually (Novozymes, 2013; Novozymes, 2015a). NZ rely on an active patent strategy to protect its knowledge and profitability. The firm has more than 7,000 granted or pending patents according to their annual report 2014 (Novozymes, 2014).

A part of NZ' strategy, "Partnering for impact", is its focus on partnerships with customers, and in their new strategy, guiding the firm from 2015 toward 2020, they seek more and closer partnerships with customers, consumers, governments, academia and people around them (Novozymes, 2014). The new long-term targets for 2020 are to reach 6 billion people with their biological solutions, educate 1 million people about the potential of biology, catalyze 5 global partnerships for change, deliver 10 transformative innovations, save 100 million tons of CO_2 and enable NZ' employees' development (Novozymes, 2014). While the strategy is about strengthening NZ' classical areas of attracting and retaining the best people and staying at the forefront of technology, in order to be the preferred partner for customers and stakeholders, it also reflects a need for them to develop outreach and communication (Novozymes, 2014).

NZ' current product development process follows a traditional stage-gate model (MKBS, 2015; CBXT, 2015). The process goes through different stages with clearly defined gate criteria and customer needs and value propositions are central throughout the process (Falholt, 2015). Prior to the formal project process is a scoping phase (MTFR, 2015), where many inputs are obtained. Already in this phase, the market potential for the idea should be established (MKBS, 2015; GIBU, 2015). In addition to market and value potential, it is important to consider IPR, specifically concerning ownership and whether it is possible to patent the idea, in order to capture commercial value, or protect the idea in other ways (MTFR, 2015; GIBU, 2015; HANS, 2015).

The innovation process is thus characterized by clear structure, evaluation criteria and commercial ends.

4.2 BiologiGaragen (BG)

BG is an open citizen community and an association for people with interest in practicing biology. It is a part of the larger interdisciplinary hackerspace Labitat, with which they share physical space (Research Europe, 2013; Kopenlab, 2015; BiologiGaragen, 2015a). The organization is non-hierarchical and all members are invited to the general assembly, which is the highest authority of the organization (BiologiGaragen, 2015a; MIAL, 2015; EMPO, 2015). Everyone can visit the space and become involved in community projects, although a becoming member, which entails a small annual membership fee, is encouraged (BiologiGaragen, 2015b). BG counts 12 internal members and 121 external members, on the mailing list, from all over the world (MIAL, 2015; BiologiGaragen, 2015c). Labitat counts 1051 members (Labitat, 2015b) and their mailing list now counts over 1000 members internationally (SSØR, 2015). The purpose of BG as it is stated on their webpage is *"to foster a culture of citizen science, and build a community laboratory for people to meet, play, do projects and share their ideas"* (BiologiGaragen, 2015a). They seek to achieve this purpose by bringing people together for collaboration and mutual inspiration in a physical open laboratory and by online knowledge sharing (Kopenlab, 2015). There are several online communication systems. BG has a website, mailing lists, newsletters and a wiki platform, which is shared with Labitat (MIAL, 2015; Labitat, 2015a). This wiki platform also includes links to the international network of DIY biologists - DIYbio.org. Findings and work are presented and shared online. Help and inputs are gathered from the online community, including global community networks, as projects are carried out (SSØR, 2015; MIAL, 2015; EMPO, 2015). Projects are freely chosen and carried out on the basis of interactions between participants and their interests and desires, and there are no formal structured processes that need to be followed (MMBO, 2015; EMPO, 2015; MIAL, 2015).

The innovation process of this open DIY community is thus fundamentally different from the product development process of NZ described in the previous section.

4.3 The Baessy Project

In 2013 NZ donated 100,000 DKK to Labitat and BG to support the development of the space (Simonsen, 2013; Riis Sørensen, 2013). The interest from NZ was motivated by an acknowledgement, that innovation is not reserved for firms and universities and that it increasingly emerges in DIY environments (Simonsen, 2013). As NZ depends on innovation and knowledge, the R&D management of the firm wanted to support the movement and be a part of it both physically and digitally (FHAT, 2015; Simonsen, 2013).

The relation advanced into a concrete collaborative project later in 2013, as Allan Alfred Birkegaard Hansted facilitated the contact between NZ and BG as part of his PhD project (nz.networksociety.org, 2015; MMBO, 2015). The initiative was approved by Ejner Bech Jensen, Vice President of Biotechnology Research, and the NZ employees involved were Gernot Abel, science manager at NZ, and Frank Hatzack and Christian Brix Tillegreen from the Business Development unit (CBXT, 2015; FHAT, 2015; GEAB, 2015).

In advance, NZ had defined precompetitive areas, areas not compromising the core of their business, they were willing to work within, to avoid obstacles of IPR and ownership (FHAT, 2015; EJBJ, 2015). The first meetings were held in August 2013 and the overall project went live in January 2014 and was named Baessy. The idea was to establish a community project for developing open source tools and assays for citizen science (nz.networksociety.org, 2015). The first Baessy project was to develop an ethanol sensor, to measure bioethanol during fermentation. Gernot Abel and Martin Malthe Borch, one of the founders of BG, became the project coordinators and most central participants, although the project was open to everyone (BiologiGaragen, 2015d; MMBO, 2015; nz.networksociety.org, 2015). The work took place in BG, where Abel joined in on a regular basis (FHAT, 2015; CBXT, 2015). This collaboration was an encounter between two very different sets of organizational logics, and Abel described it well in an article about the project on the website of NZ: "*For us it is a paradigm shift*

because we are not aiming at creating and securing IP here – it is exactly the opposite: We strive to learn and share with everybody. We hope to learn how we can accelerate R&D at Novozymes by employing smarter and lower cost approaches." (Novozymes, 2015b).
A low-cost functioning prototype of a bioethanol sensor was developed using open source software and hardware around June 2014 (nz.networksociety.org, 2015; BiologiGaragen, 2015d). So far, new Baessy projects between NZ and BG have not been initiated. However, documentation of the process and the outcomes of the ethanol sensor project has been shared online for others to work on (MMBO, 2015).

There are indications that the collaborative project with BG is the first one out of many to come (GEAB, 2015; FHAT, 2015). This type of open collaboration fits very well with the new long term strategic targets of NZ and management seem to recognize that it will be important to expand the array of collaborative partnerships beyond the current context of the business (FHAT, 2015). Untraditional collaborations with open source innovators and makerspaces hold a large potential, as they strongly multiply NZ' reach and the people engaged in these networks are highly competent within disciplines not found internally in the firm (FHAT, 2015; CBXT, 2015).

5. Results from the Qualitative Data Analysis

The 18 conducted interviews were recorded with the consent of the interviewees. All of the recordings were transcribed in their original language (Danish for 16 and English for two interviews). These transcripts are not fully word-by-word, as the added understanding from transcribing filler words was considered negligible. All transcripts were coded but the three transcripts of interviews with the external experts were not quantified in the data analysis, as it would lead to misleading results if compared with the groups of makerspace participants and NZ employees.

Statements from the interviewees were gathered in broader themes, which we term concepts. The open coding process led to a total of 1,511 coded instances of 144 distinct concepts. The concepts were then grouped into 12 overall categories. Below, each category will be introduced followed by a figure showing the results. For full explanations of the concepts please see Appendix 1. The categories and concepts shown are the ones referred to in the analysis in chapter six and the discussion in chapter seven. Some categories and concepts were considered too vague or were rarely mentioned, and were therefore not found to add value to the analysis. They are therefore not shown in the figures in order to reduce complexity. For a full list of categories and concepts, please see Appendix 2.

Results from the coding of the two groups of interviewees, the makerspace participants and the NZ employees, were kept separate, in order to distinguish between responses from the two groups. The number of mentions of a concept is shown as a percentage of the total number of mentions of all the concepts within the category, by makerspace participants and NZ employees respectively. Percentages, rather than absolute numbers of mentions, were used for comparison, as the two groups differ in size. These percentages give a rough overview of the concepts that come to mind most often, when an interviewee talks about the different categories. While category-level discrepancies can be attributed to the different questions asked, the code-level differences showed noteworthy inconsistencies between the perceptions of the two groups, as we will delve into during the analysis.

The first major category was termed 'Barriers & challenges to collaboration', which includes the concepts related to potential barriers and challenges that could hurt the possibility for firm-makerspace collaboration. Table I in the appendix shows explanations for each of the utilized concepts in the category.

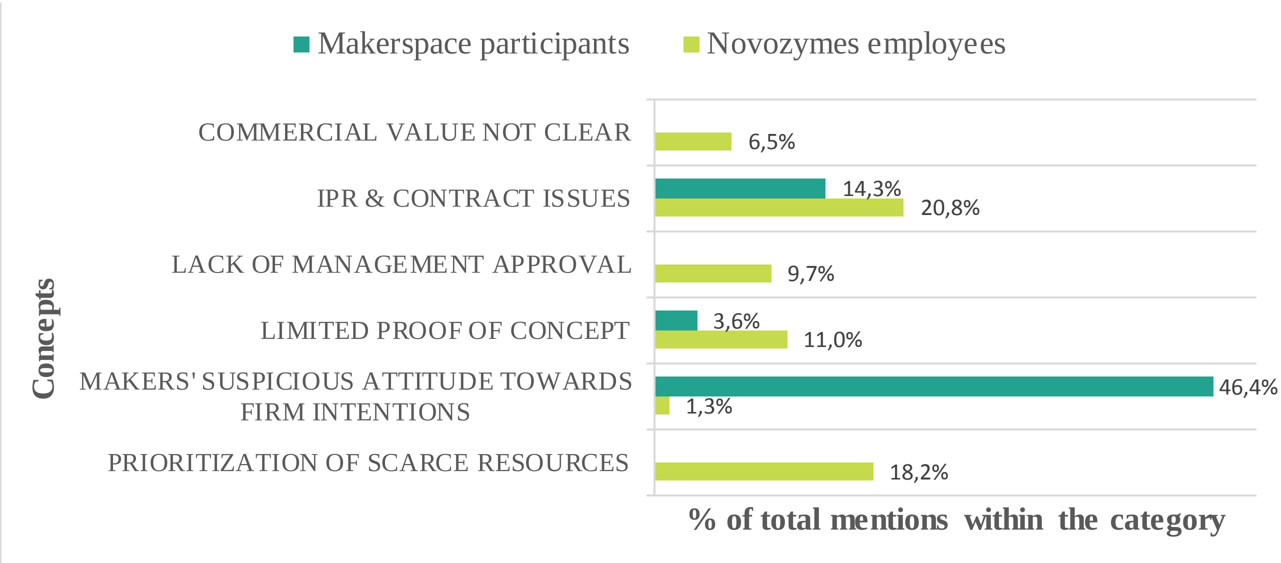

Figure 2 - Barriers & challenges to collaboration

The category 'Defining projects' includes the concepts of how project goals and topics are agreed upon by project members in firm-makerspace collaborations and in projects solely run by makerspace participants. Table II in the appendix shows explanations for each of the utilized concepts in the category.

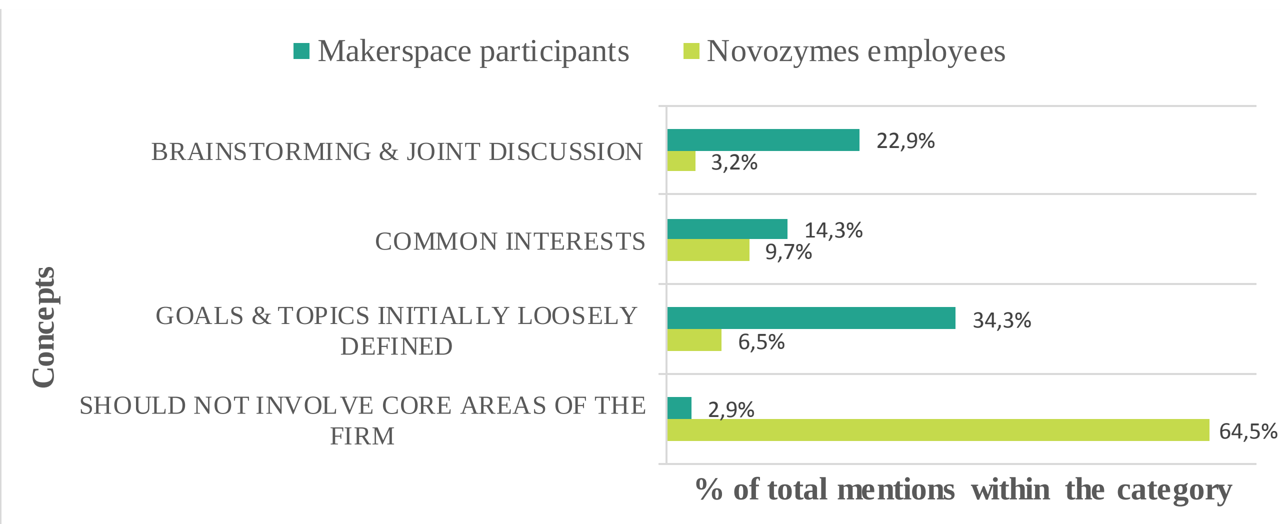

Figure 3 - Defining projects

The category 'Firm-makerspace relation' includes the concepts of how the collaboration unfolds and how the involved participants can (or should) approach the relation. Table III in the appendix shows explanations for each of the utilized concepts in the category.

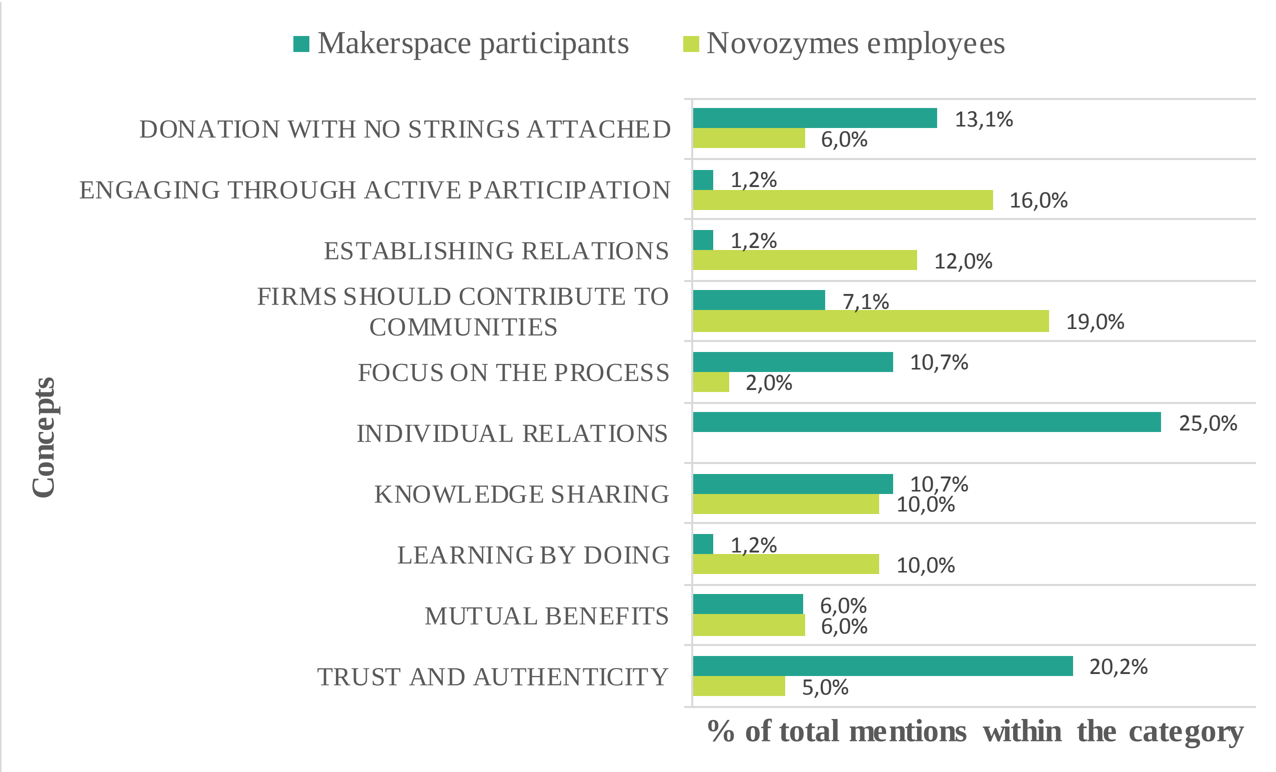

Figure 4 - Firm-makerspace relation

The category 'Governance of collaboration' includes the concepts of how collaboration is governed, and what is deemed important to the actors involved. Table IV in the appendix shows explanations for each of the utilized concepts in the category.

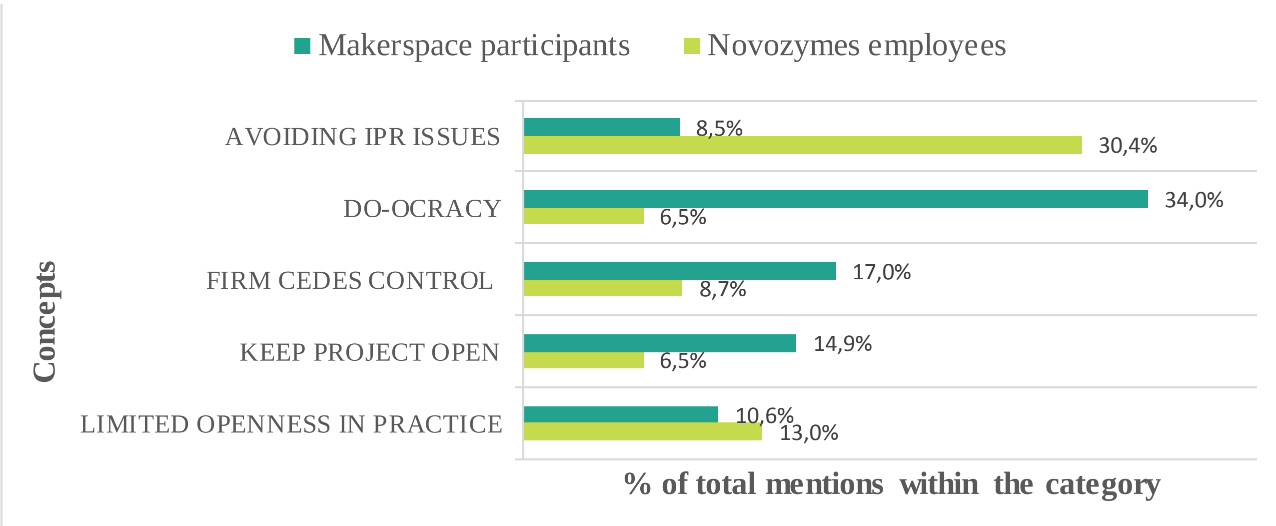

Figure 5 - Governance of collaboration

The category 'Knowledge benefits' includes the concepts of how the knowledge base of the firm can be positively affected by collaborating with makerspaces. Table V in the appendix shows explanations for each of the utilized concepts in the category.

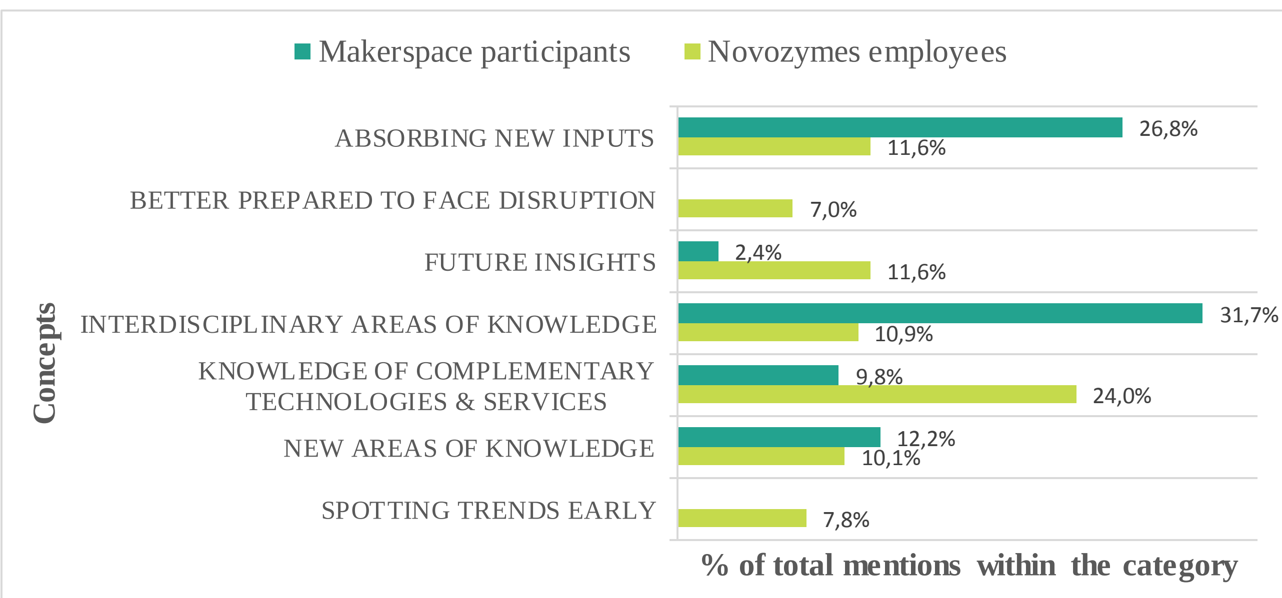

Figure 6 - Knowledge benefits

The category 'Makerspace characteristics' includes the concepts of the makerspace organization in terms of values, rules and structure, as well as the composition of the makerspace community. Table VI in the appendix shows explanations for each of the utilized concepts in the category.

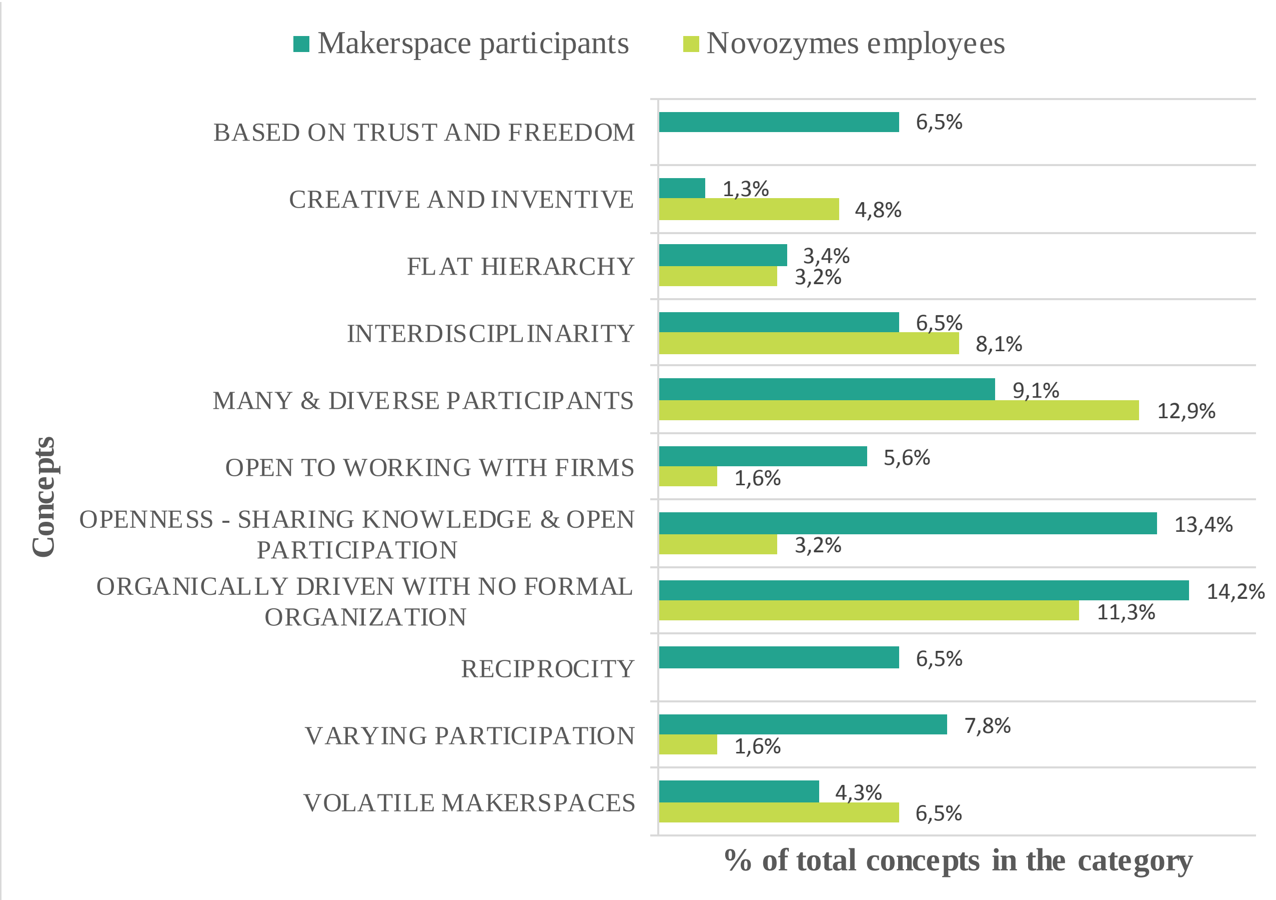

Figure 7 - Makerspace characteristics

The category 'Motivation' includes the concepts of motivation for participation in projects at makerspaces. Table VII in the appendix shows explanations for each of the utilized concepts in the category.

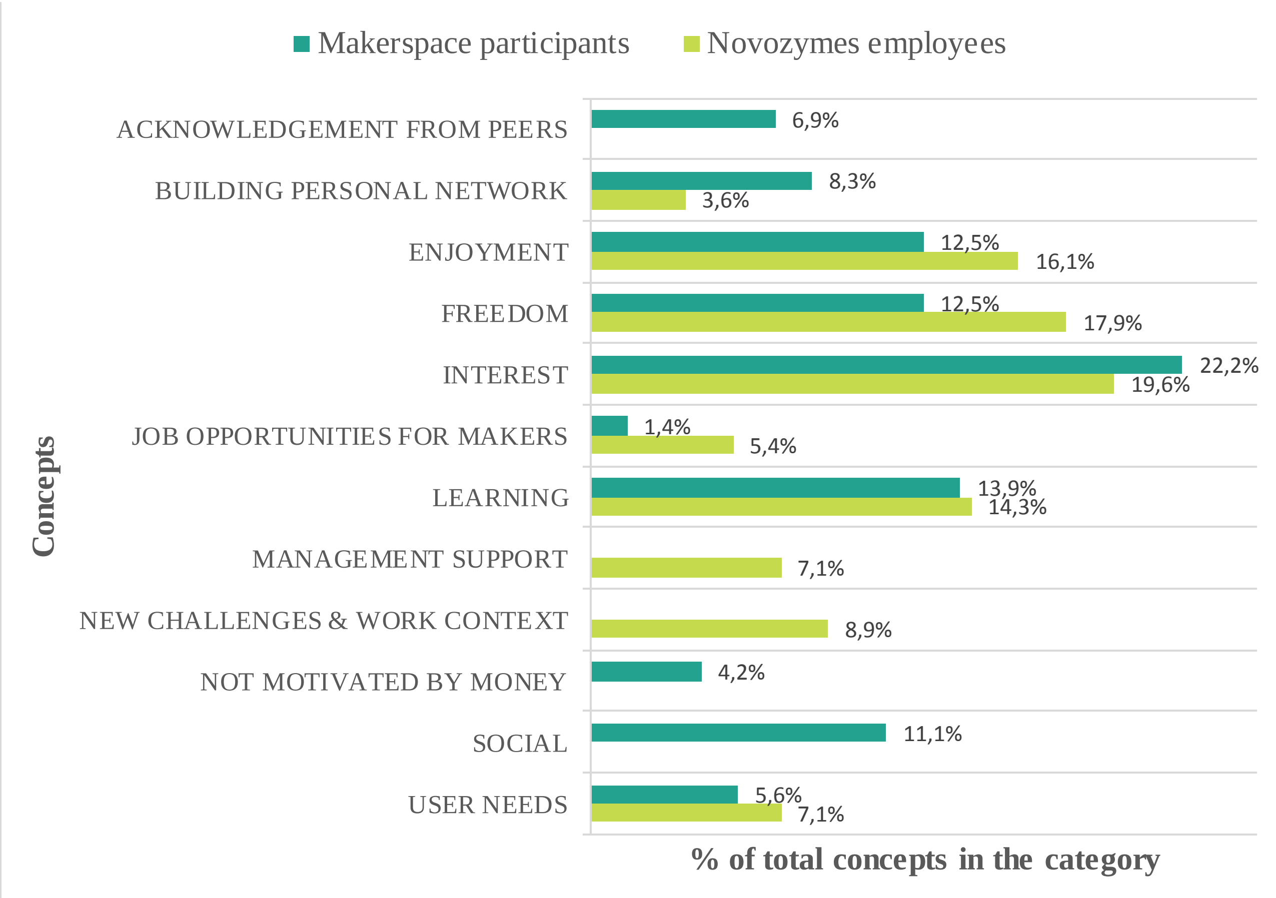

Figure 8 - Motivation

The category 'Network benefits' includes the concepts of how firm-makerspace collaboration can help NZ grow their network and how the network of the makerspace can benefit NZ. Table VIII in the appendix shows explanations for each of the utilized concepts in the category.

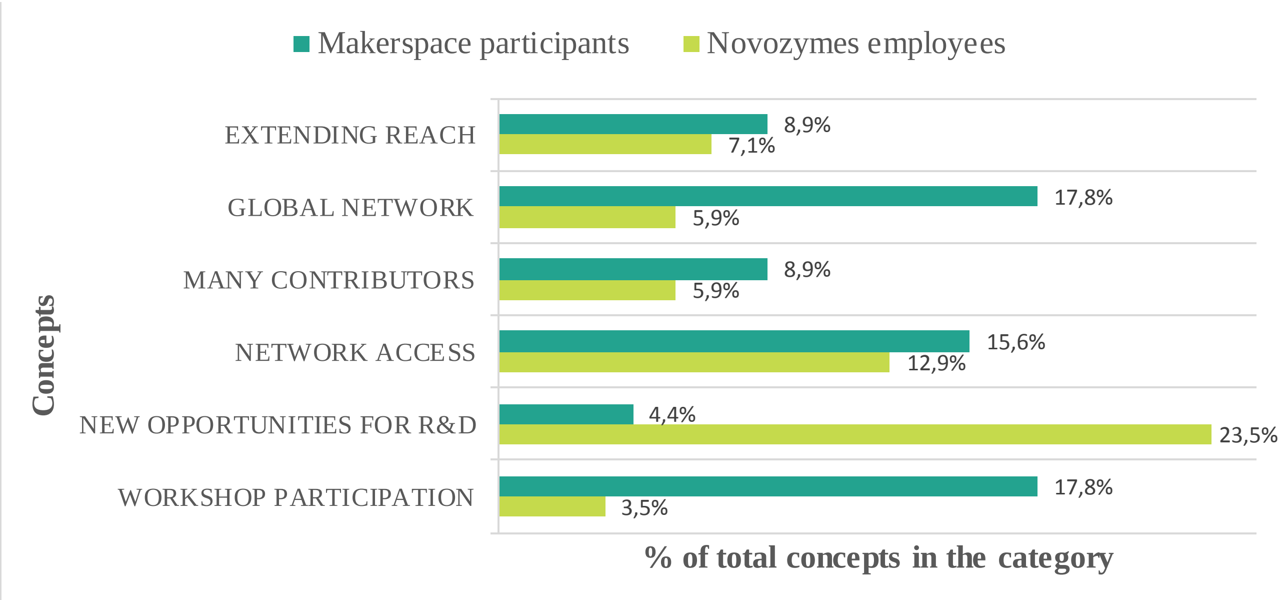

Figure 9 - Network benefits

The category 'Organizational benefits' includes the concepts of how the internal organization and processes of NZ can benefit from firm-makerspace collaboration. Table IX in the appendix shows explanations for each of the utilized concepts in the category.

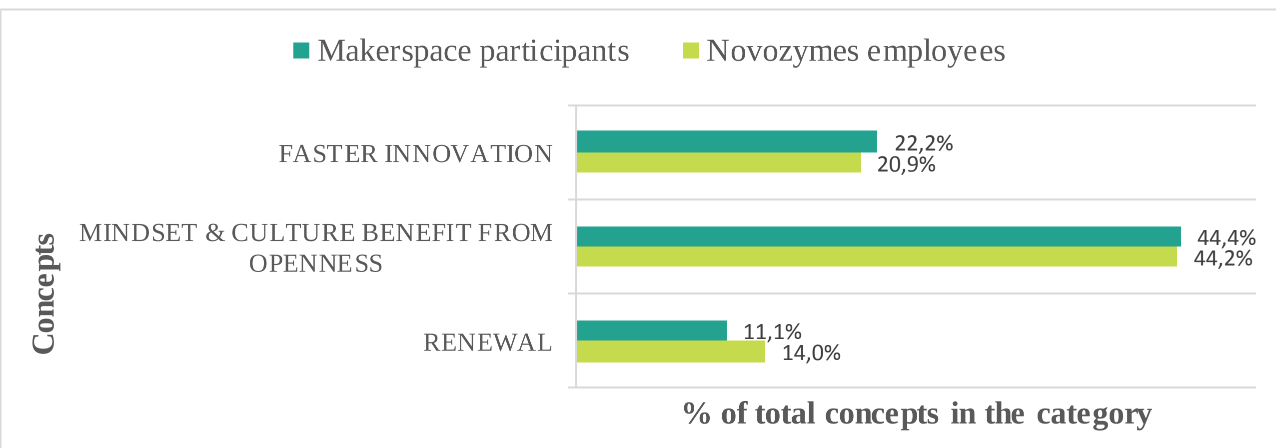

Figure 10 - Organizational benefits

Three categories included concepts only mentioned by NZ employees and are therefore shown together in Table 3. These are:

a) 'Firm characteristics', which includes the concepts regarding characteristics of NZ, particularly in relation to knowledge sharing and creation. Table X in the appendix 1 shows explanations for each of the utilized concepts in the category.

b) 'Strategic approach', includes the concepts of how NZ can implement makerspace collaboration into the overall firm strategy. Table XI in the appendix shows explanations for the utilized concepts in the category.

c) 'Uncertainty about the future', includes the concepts regarding the concerns of NZ' employees over what changes may affect the firm in the future. Table XII in the appendix 1 also shows explanations for the utilized concept in the category.

Table 3 - Firm characteristics, Strategic approach and Uncertainty about the future

Categories & concepts	% of total mentions within the category
Firm characteristics	
RELATIVELY CLOSED TRADITION AND CULTURE	7,1%
INTERNAL HOMOGENEITY	6,0%
INFORMAL INTERNAL NETWORKS	11,9%
FORMAL INTERNAL KNOWLEDGE SHARING	7,1%
FIRM INNOVATION DRIVEN BY MARKET NEEDS	23,8%
Strategic approach	
VALUE CREATION	28,6%
STRATEGIC INTEGRATION	34,3%
Uncertainty about the future	
THREAT OF DISRUPTION	40,0%

6. Analysis

The analysis is structured according to the three sub-questions of this research. Each section is divided into subsections to investigate the individual propositions of the theoretical framework presented in section 3.3.

6.1 Analysis Part 1 - How can Firm Employees and Makerspace Participants be Motivated to Engage in Firm-Makerspace Collaboration?

6.1.1 Motivation of Makerspace Participants

'Interest' is the most prevalent motivational factor for makerspace participants to engage in projects at the makerspace, closely followed by 'Learning', 'Freedom', 'Enjoyment', and 'Social' motivations (Figure 8).

Makerspace participants found 'Knowledge sharing', 'Firms should contribute to communities' and 'Mutual benefits' from collaboration to be important aspects of collaborating with firms (Figure 4). As one participant stated: "*There's a lot to learn from people in the industry and their knowledge of what can become a useful product […]A guy like Gernot is an extremely skilled scientist by his own rights […] It will always be a huge bonus with regards to biotech related problems"* (EMPO, 2015:01:02:29). Thus, there is a high learning potential in working with someone in the industry. The process of learning in itself, rather than the usefulness of product outcomes, is an important consideration, as makerspace participants enjoy making complex and interdisciplinary work (NNIS, 2015). The makerspace participant most heavily involved in the Baessy project explains how the development process taught him valuable lessons about Arduino, protocols and data use (MMBO, 2015). This 'focus on the process' is perceived as an important part of firm-makerspace relations (Figure 4), and can thus accommodate the motivational factors of enjoyment, interest and learning.

With makerspace participants seeking enjoyment and interesting challenges, their characteristics mirror those of 'hobbyists' (Shah, 2006:1006). Additionally, indications were found of makerspace participants wanting to create solutions to problems in their own daily lives, such as feeding their pets while travelling, a custom-made laptop or personal diagnostics (NNIS, 2015; MIAL, 2015). This shows a presence of the 'need-driven' participation identified by Shah (2006:1004) and in the theory of UI (von Hippel, 2005:22). However, the need-driven motivations are not as pronounced in the data as that of a more hobbyist motivation, such as enjoyment and interest (Figure 8).

With makerspace participants being motivated by the freedom inherent in makerspaces, they have a suspicious attitude towards firm intentions, when asked about working with these, as shown in Figure 2. Freedom is conceptualized by makerspace participants as the freedom to use a product or technology *"for whatever we want, however we want and under the conditions of our choosing."* (NNIS, 2015:00:55:54). This freedom is restrained if otherwise available technology, upon which they may have become reliant, is made private by a firm or individual (NNIS, 2015). This is further reflected in the prevalence of 'IPR & contract issues' as a perceived barrier to collaboration (Figure 2). Thus, there is a strong sentiment among makerspace participants, that any collaboration with firms must be based on openness (Figure 5), which ensured makerspace participants could freely use any technology created in the process (MIAL, 2015). If representatives of the firm appear authentic (Figure 4), then makerspace participants are generally willing to work with them (Figure 7). For makerspace participants, freedom is also an issue of working on what is interesting, rather than what others decide they should work on. This freedom to choose own projects is a defining feature of makerspaces, and it was mirrored in the Baessy project definition process: *"It was Gernot and I [who defined the project]. Everyone can sign up and use it as if it were their own. It is all about what the individual or the different groups want."* (MMBO, 2015:00:08:23). Thus, a collaboration that caters to makerspace participants, by involving them in the project definition process, could arguably accommodate the motivational factors of interest and freedom.

The social motivation, which is highlighted as a defining and motivational characteristic of physical makerspaces (Kostakis, et al., 2014), is one of the main appeals of participating in collaboration: *"There are of course advantages to online forums, but you are motivated the most by meeting physically and this is where the social things happen. This is where the magic happens."* (EMPO, 2015:00:52:14). Firm-makerspace relations are viewed by makerspace participants as relations between individuals (Figure 4) and firm representatives are viewed as such: *"It's not a collaboration between BiologiGaragen and Novozymes – it is to a higher degree a collaboration between me and Gernot."* (MMBO, 2015:00:03:33). The majority of makerspace participants have day jobs, but they are recognized as individuals in the makerspace, regardless of firm affiliation (MMBO, 2015). That some participate as part of their day job has hardly any impact, as long as they are seen as genuine, contributing members, since there are equal expectations for everyone (MMBO, 2015). As such, there is no indication that firm-makerspace collaborations should be any less socially stimulating than collaborations exclusively among makerspace participants.

In relation to, or perhaps as an extension of, the social aspect, are two motivational factors that were sporadically present in the data, namely 'Building personal network' and 'Acknowledgement from peers' (Figure 8). As one makerspace participant stated: *"Most of my network I've gotten through this, and I've received a certain degree of acknowledgement..."* (SSØR, 2015:00:53:25). Collaboration with firms is a new opportunity to satisfy these motivational factors, but being acknowledged by a firm employee holds no special status over the acknowledgement of other peers in the makerspace: *"It means a lot when other participants acknowledge you. It could be guys from firms – I mean it's cool with people from every background [...] Formal evaluations are not interesting."* (EMPO, 2015:00:52:14). Overall, little evidence for extrinsic motivation appeared in the empirical data apart from acknowledgement being important. While one makerspace participant made a passing reference to job opportunities, no one mentioned reputation building or money, except to announce that they were indeed not in it for the money (Figure 8).

To sum up, support was found for the presence of intrinsic motivation and the belief that such desires could be (and have been) fulfilled in firm-makerspace collaboration. Extrinsic motivation hardly appeared in the empirical data. The findings thus indicate support for Proposition 1.a:

Proposition 1.a: Makerspace participants will primarily be motivated to engage in collaboration by intrinsic motivational factors, such as enjoyment, learning, challenge, freedom and social interaction.

6.1.2 Motivation of Firm Employees:

Regarding firm employee motivation to engage in collaboration, the same overall focus on intrinsic motivational factors was proposed. From the interviews, it became apparent that not everyone in the firm would be interested in working outside their normal work environment (HANS, 2015) or in moving outside the firm in general: *"[...] we are not all extremely extrovert and jump around with ideas"* (MKBS, 2015:00:20:02). However, there was a general openness to participating in such endeavors among the NZ employees, who expressed that new challenges and work contexts were motivating (Figure 8).

For NZ employees 'Interest', 'Freedom', 'Enjoyment', and 'Learning' were the four most prevalent motivational factors, as it was for makerspace participants (Figure 8). NZ employees saw a firm-makerspace project as a good place to learn, as the number of references to 'Knowledge sharing' and 'Learning by doing' suggests (Figure 4). While working on the Baessy project in the makerspace, the employee specifically mentioned how he learned to use Open-Source microelectronics (GEAB, 2015). NZ employees who have yet to participate in collaborations with makerspaces are also open to the idea, as it caters to interests, enjoyment, and learning: *"I just like to learn new stuff I think. [...] It would be a fun place to learn about things that you wouldn't necessarily learn normally."* (JEEQ, 2015:00:28:36).

The freedom to choose your own project and be creative when working in makerspaces is also appealing. As one employee stated: *"So most [of us scientists] would love going out and participating and using the freedom to come up with ideas and not think about, whether it is something we need to protect or if it is something we can tell about, and just build on each other's ideas. It is a bit like returning to your creative childhood."* (FIOD, 2015:00:17:53). These terms were satisfied in the Baessy project, where IPR issues were avoided and the process was technology driven without focusing on an end market or commercially viable product (GEAB, 2015; CBXT, 2015).

One issue that appeared in the empirical data, however, was a reluctance to actually participate in makerspace collaborations. NZ employees enjoyed entertaining the thought and were certainly motivated by the prospects of enjoyment, freedom, and learning, but in practice, they had a major concern: *"But I'm not sure I could get my managers convinced that I should spend an entire day each week doing it. Even though I would find it fun. If I had the time, I would like to go."* (MTFR, 2015:00:27:34). While 'Management support' as a motivational factor is only mentioned sporadically (Figure 8), it alludes to a larger issue. In the category of 'Barriers & challenges to collaboration' the concepts of 'Prioritization of scarce resources' and 'Lack of management approval' were frequently mentioned (Figure 2). Thus, NZ employees do not themselves express management support of their involvement with makerspaces as a motivational factor, as much as they talk about a lack of approval as a barrier. This indicates that there is a presence of some extrinsic motivational effect of management support, although it is difficult to categorize. There is a similarity here, to Hertzberg's 'Motivator-Hygiene' theory (Larsson, 2010:36), in that lack of management approval is demotivating with regards to collaborating with makerspaces, but support is not necessarily motivating in the same way that the intrinsic factors were demonstrated to be. Rather, management approval for prioritizing resources towards such projects can be argued to be a minimum requirement to avoid negative motivation.

To sum up, the above analysis indicates support for Proposition 1.b:

Proposition 1.b: Firm employees will be motivated to engage in collaboration in makerspaces by experiencing freedom and creativity as well as the challenge of working on interesting tasks not found in their daily work environment.

Additionally, the analysis showed that enjoyment and learning were important motivational factors, and that lack of explicit management approval has a demotivating effect.

6.1.3 Preemptive Generosity: Establishing a Relation

Making contributions to the community, which participants find valuable, is essential to motivate them to reciprocate the contributions (Spaeth, et al., 2010). The contribution can take many forms, among others pecuniary donations, knowledge and technology or equipment (Dahlander & Magnusson, 2005; Spaeth, et al., 2010). These insights were supported, since all makerspace participants interviewed mentioned contribution, in some form, as a key element of collaboration. As shown in Figure 7, an important characteristic of makerspaces is 'reciprocity'. One interviewee stated that in order to be a part of the makerspace one have to contribute to the makerspace (SSØR, 2015). In addition, if one asks for help with a project, makerspace participants will be motivated to help if they perceive that this effort will be reciprocated. The important thing, however, is the gesture and act of paying back, not the "currency". Whether paying back is done through knowledge, effort or pecuniary donations to projects or to the community, has little influence (NNIS, 2015; MMBO, 2015; SSØR, 2015). Rather, to motivate makerspace participants to participate in a project, one should appeal to the concept of reciprocity. If makerspace participants are to expend effort, they must perceive the relation to be fair, as fairness is an essential part open collaborations (Spaeth, et al., 2010). Thus, while a donation of money may seem to be an external motivational factor, it is not pursued as such by makerspace participants, but rather is seen as a signal of intent to create an equitable situation. Reciprocity, then, is a conceptualization of how makerspace participants are intrinsically motivated to engage in equitable work efforts. The interviews thus underline the motivational factor of initial contribution, and indicate that one can contribute in many ways in order to motivate reciprocal effort.

When talking specifically about the relation between firm and makerspace, the makerspace participants strongly underlined that any donations, whether pecuniary or non-pecuniary, from firms should be with no strings attached (Figure 4). An important premise for accepting donations from firms is that knowledge should always stay open (MIAL, 2015). In addition, firms donating are not buying any power or influence, since an important part of the makerspace idea is to stay financially independent (MMBO, 2015) and make no long term commitments: *"We have received several donations in the past, often equipment from firms. The most important part has been that it should be with no strings attached. It was fine to have a joint project, but there should be no long term demands or dependencies […]"* (SSØR, 2015:00:23:04). These findings are aligned with the motivational factor of freedom found among the makerspace participants (Figure 8). Thus, although 'preemptive generosity' (Spaeth, et al., 2010:423) is found to motivate external contributions, any initial contributions should not compromise the freedom of the makerspace participants. Indeed, an interesting finding, which supports the importance of establishing a context for sharing and contribution through preemptive generosity, is the suspicious attitude towards firm intentions found in interviews with makerspace participants (Figure 2). Preemptive generosity, then, can help a firm build valuable relationships, which can facilitate knowledge sharing and creation by building trust and establishing norms for sharing (Spaeth, et al., 2010), if performed carefully to avoid provoking suspicion. An important characteristic of makerspaces is that they are 'Based on trust and freedom' (Figure 7) and 'Trust and authenticity' was one of the most frequently mentioned concepts in the category 'Firm-makerspace relation' (Figure 4). According to several makerspace participants, it is very important initially to show a willingness to participate and contribute as well as being transparent about intentions, because then people will be more likely to join or help with the project (NNIS, 2015; SSØR, 2015). Indeed, trust can be difficult to establish in such a relation (MMBO, 2015), but preemptive generosity, when accompanied by transparency about intentions, can thus be understood as a way to reduce the suspicious attitude from makerspace participants.

Supportive to the motivating effect of preemptive generosity, is the idea of 'proactive attention', which has a positive effect on getting external input especially in the early stages of a project (Dahlander & Piezunka, 2014:819). Given the makerspace participants' emphasis put on the initial show of engagement and willingness to participate, firms can get more inputs from external contributors by being proactive. Indeed, taking initiative is required to make something happen and get inputs from makerspace participants (SSØR, 2015). Findings from the interviews thus support the motivating effect of preemptive generosity including proactive attention, which seem to be key activities for establishing a collaborative relation between makerspaces and firms.

It then becomes interesting to investigate how this aligns with how the relation is perceived by NZ employees. Answers from the interviews with NZ employees, indicate a clear understanding among the employees that 'Firms should contribute to communities', 'Engaging through active participation' and 'Knowledge sharing' are important elements of the relation. In addition, 'Mutual benefits' and 'Donation with no strings attached' were recognized although less frequently (Figure 4). Thus, the answers from makerspace participants and NZ employees are fairly aligned and support each other. However, one important aspect of the relation found in responses from makerspace participants, is the emphasis on 'Individual relations' (Figure 4). Collaboration in makerspaces is between individuals and not organizations (MMBO, 2015). When trying to establish a relation it then becomes important that employees go there as individuals: *"In reality it is easiest to say, that you can be here as a person"* (SSØR, 2015:00:59:34). Interestingly, this aspect was not mentioned at all by NZ employees (Figure 4). These findings indicate that preemptive generosity should be performed on the individual level, more than on the organizational level, and that firms need to build more awareness of this aspect.

Just prior to the Baessy project, NZ donated 100,000 DKK to BG (CBXT, 2015). This donation was a generous gesture to help develop the place (SSØR, 2015), and NZ did not buy themselves power nor did they make any demands (MMBO, 2015). Thus, this action can be understood through preemptive generosity. Furthermore, the donation led to further investment in the relation, when NZ dedicated one of their most skilled employees to work in BG. The objective was to establish a relation, find a project and carry it out (FHAT, 2015). From the early beginning it was clearly stated that this was a joint effort: *"[…] it was important from the beginning to make it clear that it was a joint effort that should benefit both sides. BiologiGaragen should not just be sponsored by an amount of money, that doesn't cover much, but should be supported in other ways*" (GEAB, 2015:00:08:14). The project was decided through open discussions and brainstorming (MMBO, 2015; GEAB, 2015). This initial openness and transparency can be assumed to have facilitated the creation of trust, since it aligns strongly with the requirement of authenticity (Figure 4) and the most significant makerspace characteristics, such as the inherently open nature of makerspaces, whereby knowledge is shared and participation is open and voluntary (Figure 7). The NZ employee contributed to defining the project and making it happen (MMBO, 2015), thus exerting proactive attention. Indeed, he showed a personal interest and enthusiasm and was very engaged and committed (MMBO, 2015). The importance of this behavior was very clear: "*You have to engage. Then you will get something back. And that was what Gernot did [...] And that is what does the trick. If he hadn't, then I think things would have turned out quite differently*" (MMBO, 2015:00:20:54). The employee himself experienced the importance of contributing: "*It was a new experience, that if you just contribute then you can join in*" (GEAB, 2015:00:11:55). By contributing with his effort, input and enthusiasm, preemptive generosity was exerted on the individual level by the employee. Indeed, the empirical findings indicate that the individual effort was what really mattered, compared to the organizational effort in the form of the donation. It was the engagement of the employee rather than the donation that motivated makerspace participants to engage in the Baessy project. To sum up, an analysis of the Baessy project supports the notion of preemptive generosity and proactive attention to motivate external contributions, and thus Proposition 1.c:

Proposition 1.c: Firms can motivate makerspace participants to engage in collaboration through preemptive generosity, as long as contributions carry no obligations for makerspace participants.

Additionally, the motivational effect was greater at the individual level than the organizational level.

6.1.4 Merging the Stages of 'Defining' and 'Finding Participants'

In the two first stages of the process model for ICOI, the firm defines the project, and then attempts to find and attract participants (Piller & West, 2014). However, the process is quite different in practice. The Baessy project was defined and developed through a joint effort between makerspace participants and the NZ employee. This is aligned with how the process of defining projects in general is conceptualized in the minds of makerspace participants. Makerspace interviewees emphasized the concepts 'Goals & topics initially loosely defined', 'Brainstorming & joint discussion' and 'Common interests' in the category of 'Defining projects' (Figure 3). These concepts indicate that projects in general emerge through interactions between participants, and the idea of firms presenting predefined problems to be solved, is therefore contested in the context of firm-makerspace collaborations. In addition, the motivational factors of freedom and interest, outlined in section 6.1.1, may be compromised if makerspace participants are not included in the project definition process. Based on the motivational factors and the findings related to the project definition process in firm-makerspace collaborations, the distinction between the stages 'Defining' and 'Finding participants' (Piller & West, 2014:40), then becomes moot. Indeed, findings from the analysis indicate that these stages occur simultaneously, are mutually dependent and that this has a positive motivational effect.

Interestingly, NZ employees focused less on the process of defining the project, but rather on the content of the project, namely that it 'Should not involve core areas of the firm' (Figure 3). One explanation may be that only few NZ employees have had experience with firm-makerspace collaborations, but it could also reflect that NZ' structured project process, including predefined criteria and goals, is ingrained in employee mindsets. However, considering the motivational factor of freedom to choose their own projects based on interest rather than commercial potential, found in section 6.1.2, employees could arguably be motivated to adopt a project definition process of a more emergent nature.

As NZ were interested in a project defined around a non-core area (Figure 3), it also makes practical sense to include external participants in the process of defining projects, as these participants could arguably have knowledge and ideas in areas unfamiliar to NZ. As an employee stated: *"Why participate in partnerships? Because we don't know the reason yet!"* (MTFR, 2015:00:28:51). This is not to say that there was absolutely no consideration of the project before NZ made contact with BG, also outlined in section 4.3, but the project specifics was defined jointly with the makerspace participants.

6.1.5 Conclusion of Analysis Part 1

Makerspace participants were found to be motivated to engage in open collaboration primarily by intrinsic motivational factors. They were motivated by; a) working on projects in areas of personal interest and challenging projects, b) personal learning and development through the collaboration processes of a project, c) having the freedom to form their own projects, decide what they want to work on and avoid any formal or long term commitments and d) the social aspect of being part of a project and interact with other participants. The mentions of extrinsic motivational factors were few but included acknowledgement from peers and the possibility to build a personal network. Support was thus found for Proposition 1.a.

NZ employees were also motivated to engage in open collaboration in makerspaces primarily by intrinsic motivational factors. They were motivated by; a) the opportunity to learn and develop new skills, b) enjoyment of working in makerspaces, c) freedom to be creative and define and choose own projects and d) interesting new challenges. Proposition 1.b was therefore supported. Moreover, the positive motivational effect of enjoyment and learning were additional findings. Additionally, management support and feedback was found to be a prerequisite for the intrinsic motivational factors to flourish.

Preemptive generosity was found to encourage makerspace participants to engage in open collaboration with firm employees, and the contributions could take the form of donations, both pecuniary and non-pecuniary, and efforts made in community work and projects. It was, however, the act or gesture of contributing that mattered, rather than the specific type of contribution. Further, makerspace participants did not pursue contributions from the firm as a reward of engaging in collaboration, instead the motivational effect came from the importance of a fair and equal contribution and the feeling of reciprocity. Proposition 1.c was thus supported. The motivational effect, however, was found to be strongest at the individual level, which indicated the importance of personal contributions, made by firm employees in the projects, rather than donations from the firm to the makerspace as a whole. Most importantly, any contributions should be with no requirements of obligations, since this would compromise the motivational factor of freedom.

The conclusion to the first sub-question, *"How can firm employees and makerspace participants be motivated to engage in firm-makerspace collaboration?"*, is thus, that both groups of individuals are motivated primarily by intrinsic factors, and that open collaborative projects should be defined and developed together by firm employees and makerspace participants to cater for and reinforce these intrinsic motivational factors. Consequently, the separation of the stages of 'Defining' and 'Finding participants' was not a useful distinction. Finally, the gesture and act of commitment and contribution was found to motivate makerspace participants to reciprocate the contributions and thus engage in a collaborative effort.

6.2 Analysis Part 2 - How should Firm-Makerspace Collaboration be Organized and Governed?

Having investigated the importance of motivation in the first two stages of the process model for ICOI, this section explores how the firm should organize and govern the collaboration process, which are key activities in the 'Collaborating' stage (Piller & West, 2014:44-45).

6.2.1 Continuous Commitment: Maintaining an Interactive Relation

Although preemptive generosity was found to be motivating, initial contributions made by the firm and its employees are not enough to sustain motivation and thus contribution. Firm employees must consistently contribute to the community following a norm of reciprocity by giving and receiving ideas and knowledge to sustain motivation (Shah, 2006; Spaeth, et al., 2010). The empirical findings strongly support this notion. 'Knowledge sharing', 'Firms should contribute to communities' and 'Mutual benefits' were underlined by makerspace participants as important elements in the 'Firm-makerspace relation' (Figure 4). Findings from interviews with NZ employees were consistent, since the four most frequently occurring concepts in the 'Firm-makerspace relation' category were 'Firms should contribute to communities', 'Engaging through active participation', 'Establishing relations' and 'Knowledge sharing' (Figure 4). The perception was clearly expressed by an employee: "*The idea is not for people to use the system that is not the point of the system. You have to give something back.*" (JEEQ, 2015:00:23:24). In addition, 'Reciprocity' was found to be a fundamental characteristic of makerspaces (Figure 7), and anyone participating in makerspace projects should adopt this norm: *"[…] it is a give and take on all projects […]"* (EMPO, 2015:01:00:55) and *"[…] if you take some knowledge from us ideally support us with some money, tools, some equipment or time or anything.*" (MIAL, 2015:00:49:49). Some firms have tried to utilized the makerspace by asking questions on mailing lists or asking participants directly to solve problems, but the answer has been "no". To get help and advice, one needs to participate, contribute and engage continously (MMBO, 2015; SSØR, 2015). This aligns with Dahlander & Wallin (2006), who found that firms can benefit from communities as complementary assets, but have to gain access to the knowledge and work by dedicating employees to participate over time: "*Firms that want to participate in communities therefore must do so as peers (i.e. they must allow their employees to work in these communities as peers). Access to communities allows firms to get access to resources that cannot be bought in the market*."

(Dahlander & Wallin, 2006:1247). The notion of participating as peers was also found in the empirical data: "*[…] how do you make everything work in such an anarchistic place, I think it requires that everyone is there on equal terms*" (NNIS, 2015:00:58:52). The above findings resonate with the strong focus on individual relations mentioned in section 6.1.3, and indicate that while contributing with equipment, donations and effort initially may be enough to gain access to the community, continuous contribution on the individual level is needed to maintain access to the community.

This can further be explained by the concept of a 'symbiotic approach' where the firm focuses on the realization of mutual benefits for both firm and community (Dahlander & Magnusson, 2005:488), which in turn increases motivation for contributors (Shah, 2006). The importance of reciprocity found in our empirical data has already been outlined above and in section 6.1.3. In contrast, taking a 'commensalistic approach', where firm employees simply seeks to gather useful input from the community without actively participating (Dahlander & Magnusson, 2005:487-488), was found to be demotivating for makerspace participants. One participant stated: *"[…] if a guy from Novozymes, Microsoft or whatever wants to participate, that's fine, you can do that, but if you are paid to poach projects or people, then I think it is weird, because then you have a hidden agenda*" (NNIS, 2015:00:58:12). Similarly, if someone asks people questions or ask them for help, but won't tell what it is for, then nobody wants to help (SSØR, 2015). In the Baessy project, the NZ employee dedicated some of his time each week to work on the project in BG, and was thus continuously contributing to it (FHAT, 2015). He was not just sent to sniff out ideas and projects. It was indeed the active contribution that made the collaboration successful (MMBO, 2015). The approach taken can thus be characterized as symbiotic, and this approach helped to increase engagement from the makerspace participants.

Based on the analysis above the best way to exert continuous commitment is thus to have employees working regularly with makerspace participants on joint projects, rather than simply contributing with donations or equipment or having employees go there simply to look for useful projects or ideas. Proposition 2.a, is therefore supported:

Proposition 2.a: Firms should maintain an interactive relation, by dedicating resources, in the form of employees, to actively participate in makerspaces in order to increase motivation and engagement from makerspace participants.

6.2.2 Trust and Influence through Continuous Commitment

The sections below will analyze the possibilities for firm employees to build trust and to gain influence through continuous commitment.

6.2.2.1 Building Trust

Maintaining an interactive relation is not without challenges, although several makerspace participants mentioned that the community in general were 'Open to working with firms' (Figure 7). As mentioned in section 6.1.3, 'Makers' suspicious attitude towards firm intentions' was by far the most frequently mentioned barrier to collaboration for makerspace participants (Figure 2). Moreover, 'Trust and authenticity' in firm-makerspace relations was essential to makerspace participants (Figure 7). There is an initial cautiousness to working with firms rooted in cautionary tales from other communities and the fear of firm employees poaching projects (SSØR, 2015; NNIS, 2015). Indeed, it may be difficult for employees to prove that they are not pushing corporate agendas and to build trust (MMBO, 2015). According to Dahlander & Wallin (2006), the suspicious attitudes from other makerspace participants will force the firm employees to be more active: *"To break through the institutional protection against firm intervention, sponsored individuals need to build legitimacy. Legitimacy in a professional network is achieved through proof of skillfulness, and providing help to other individuals in the community*." (Dahlander & Wallin, 2006:1247). This was mirrored in the empirical data, as legitimacy and trust was found to be facilitated by displaying personal contribution (SSØR, 2015). In the Baessy project, the NZ employee's enthusiasm and engagement was recognized positively by several participants, including some who had not been involved in the project (NNIS, 2015; EMPO, 2015; MMBO, 2015). This further indicates the positive effect of making strong contributions on reputation and trust building.

According to theory, strong contributions will in turn increase the individual's likelihood of being identified as and becoming a community leader (Dahlander & O'Mahony, 2011; Faraj, et al., 2015; Fleming & Waguespack, 2007). In fact, leadership depends strongly on trust and the mobilization of peers in the context of open communities, where there is a lack hierarchical authority and formal structure (Fleming & Waguespack, 2007). Findings from the empirical data indicates rich possibilities to make the efforts needed to gain trust and leadership. 'Organically driven with no formal organization' and 'Flat hierarchy' were concepts frequently mentioned as 'Makerspace characteristics' (Figure 7). In the category 'Governance of collaboration' the most frequently mentioned concept was

'Do-ocracy' (Figure 5). More specifically, about do-ocracy, it was stated that if individuals take initiative to do something, they are also the ones who decide (GEAB, 2015; EMPO, 2015; MIAL, 2015). When initiating a project, communication about the project and coordination are key activities and are often enough to encourage others to join (SSØR, 2015). This resonates with how to achieve 'lateral authority' proposed by Dahlander & O'Mahony (2011:962). People with lateral authority are at the center of projects, often having increased responsibility of coordinating collective work, but without supervising others as with hierarchical authority (ibid). While hierarchical authority would compromise the freedom aspect of motivation for makerspace participants, there are in fact indications of a need for lateral authority in makerspaces: *"[…] if done in the right way, I definitely see the possibility to fill out some of these roles, that are sometimes missing in some hackerspaces or makerspaces, to be a driving force and be the one who has a plan […]"* (SSØR, 2015:00:36:21). Thus, empowered by the do-ocracy, firm employees can get to the center of projects, by making strong efforts to take initiative and responsibility and thereby gain lateral authority.

Thus, there are indications that high activity, strong contributions and gaining leadership, in the form of lateral authority, by taking responsibility and initiative can build trust. The more projects an individual initiates or participate in, the better other participants get to know that person, and this builds legitimacy. This presents a valuable opportunity for firm employees to overcome the trust barrier, which is especially evident for individuals working in a makerspace as a part of their job. This approach was also clearly depicted in the interviews with NZ employees, where 'Engaging through active participation' was the second most frequently mentioned concept of 'Firm-makerspace relation' (Figure 4).

Firm employees, then, have to be active and to build trust. They are in a favorable position to do this, as they may have a resource advantage compared to voluntary participants, because they go there as part of their job and therefore have the possibility to commit more time and resources (Dahlander & Wallin, 2006). In the interviews with makerspace participants, time was found to be a constraint. It can be hard for makerspace participants to keep up regular activity or initiate projects, when they have a family and a day job to tend to (EMPO, 2015; NNIS, 2015). In addition, the effort required to start a project, plan it and coordinate it was sometimes too much for voluntary participants, and some of the central individuals may even burn out (SSØR, 2015). Thus, consistent with theory, the findings indicate that employees have the possibility to be more active and initiate more projects since they are not constrained by time in the same way as makerspace participants. A consequence of this, is that they are also presented with the opportunity to form many ties to many different people. The more time and resources an individual can commit, the more people and groups one can arguably engage and interact with. 'Establishing relations' was the third most frequently mentioned aspect of 'Firm-makerspace relation' in interviews with NZ employees (Figure 4). This focus on establishing relations resonate with the earlier analysis of the need to build trust on an individual basis. When participating in work at makerspaces, one can rapidly grow a large network: *"[…] you can grow a network extremely fast. You will quickly get vouched for, like on LinkedIn, if someone has vouched for you, then you are in some way, because you are a part of this culture, then we know that you are not there to con anyone"* (SSØR, 2015:00:10:01). This effect applies both locally and across national boundaries, because one becomes part of an international network (SSØR, 2015). Together, the potential to initiate and participate in projects and the network access, indicate an opportunity to strengthen social ties, and thus social capital, which in turn increases the likelihood of attaining leadership (Faraj, et al., 2015). In addition, individuals can span boundaries when engaging with different groups in the network. 'Boundary spanning' includes coordination, communication and knowledge sharing across subproject boundaries, internal community boundaries and organizational boundaries (Dahlander & O'Mahony, 2011:964; Fleming & Waguespack, 2007:169). First, although BG is situated in the same location as Labitat, there is still some separation between the two associations due to different interests (NNIS, 2015; SSØR, 2015), and because of the large degree of freedom, sometimes people are working in solitude (GEAB, 2015). This aligns with the notion that the boundaries within open communities usually demarcate distinct technological areas, and are implemented by participants' decisions of where to invest their voluntary efforts (Fleming & Waguespack, 2007). Thus, the participants' different technological interests create internal boundaries in the community. In addition, the work activity is often on a project basis, which means the individuals get together in small groups, and some people only participate on a temporary project basis (EMPO, 2015; NNIS, 2015). Indeed, BG is more a network of individuals than an organized entity in itself, and in this network of individuals there are different groups (MMBO, 2015). The above indicates that projects form distinct groups, and there may even be distinct groups within the same project, which in turn enables an active participant, engaged in several projects, to span both subproject and internal community boundaries. Second, BG is connected to a larger network called FUGT, that tries to incorporate and connect all biology initiatives in Copenhagen: "*The idea is that anyone that wants to do something with biology can contact FUGT and then they will see different labs, spaces they can go to or artists they can contact, or firms they can work for or collaborate with*" (MIAL, 2015:00:39:37). This presents a way to cross organizational boundaries as well by engaging different institutions and communities. Finally, important 'Network benefits' from working in makerspaces are 'Global network' and 'Workshop participation' (Figure 9). By being a part of the network, projects can quickly go into many different directions or fields (MMBO, 2015) and people often get invited to other countries for festivals, workshops and other events (MMBO, 2015; EMPO, 2015; MIAL, 2015), which enables the participants to collaborate across international boundaries.

One of the makerspace participants interviewed can indeed be described as a boundary spanner, as she is working on a project with people from Germany and Switzerland. Furthermore, they travelled to an event in Italy to develop the project and had some participants flown in to participate in a local workshop at BG (EMPO, 2015; MIAL, 2015). Together, this group spanned both international, organizational and internal community boundaries. Relating this to the leadership discussion, several studies found that community boundary spanning increases a member's likelihood of becoming a community leader (Dahlander & O'Mahony, 2011; Fleming & Waguespack, 2007). While the above mentioned participant was a boundary spanner, it was not explicitly expressed in the interviews, whether she was seen as a community leader or not. However, the vast amount of opportunities to span boundaries, form many ties and thus strengthen one's social capital, presents an interesting path for firm employees to obtain community leadership, in the form of lateral authority.

In addition, taking initiative to start a project, communicate it to the network, help document the process and bring relevant people in from different groups, is more important to make the project succeed than the individual's knowledge of the specific field (SSØR, 2015; MIAL, 2015). Empirical findings were thus consistent with the argument, that the technical contributions were less important than the communication and coordination efforts across boundaries (Dahlander & O'Mahony, 2011). This finding further broadens the scope of technological fields that firm employees can initiate projects within.

6.2.2.2 Influence

Adding to the above analysis of how to build trust and obtain leadership in the form of lateral authority, the opportunity to gain influence will be analyzed below. The question is whether the activities carried out to obtain lateral authority and trust also enable influence, considering the very informal structure, flat hierarchy and volatile nature of makerspaces (Figure 7). Although firms cannot directly control the community or its participants, Dahlander & Magnusson (2005) propose several means of subtle control, where two mechanisms are 'devoting personnel to work in or with communities' and 'creating and maintaining reputation' (Dahlander & Magnusson, 2005:490). This is in line with the finding that firm employees who are well-connected to influential individuals in the community network, enable the firm to influence the direction of development to some extent (Dahlander & Wallin, 2006). As the below analysis will show, there is a link between lateral authority and influence, but this influence has its limitations. The empirical findings show that influence resides naturally with the individuals who take action and make things happen, thus influence is closely connected to the concept of a do-ocracy (Figure 5). Influence is strongly correlated with the level of engagement (MMBO, 2015), and it may be a result of social dynamics: *"Like in all social contexts, there will be, maybe not a hierarchy, but there is differences in who takes initiative [...] Responsibility is being shifted from person to person [...] To a very high degree, if you take initiative, then you are also the one who can decide how it is done, and everybody can do this [...] It is often people who make broad initiatives who get others to join"* (EMPO, 2015:00:55:17). This indicates that the individuals at the center of projects, the people with more lateral authority, have the possibility to influence the direction of the project. In the Baessy project, it was primarily the two central people, one of them the NZ employee, who decided what to do and how to do it (MMBO, 2015). This shows how employees can keep track of progress and influence decisions by working in projects as peers (Dahlander & Magnusson, 2005). There is thus a connection between actively participating and gaining influence. The influence, however, does not include the authority to decide over others and their efforts. As mentioned, 'Freedom', 'Enjoyment' and 'Interest' were primary motivational factors for contributing to open collaborations (Figure 8) and participants can join and leave projects at any time (MIAL, 2015). The nature of influence lies more in the ability initiate projects that are interesting for makerspace participants (MMBO, 2015; MIAL, 2015) and valuable to the firm and then motivate people to join these projects: "*You can't be sure beforehand that people want to join in. It is all about one's ability to motivate and create ideas*" (EMPO, 2015:00:26:29). As described in section 6.2.1, makerspace participants' motivation to continually engage in collaboration is contingent on firm employees themselves engaging in project work. Thus, there is a connection between continuous commitment and the ability to motivate and to influence. The earlier proposed argument about the positive effect of strong contributions on trust building further supports the link between continuous commitment and influence, since it has been found that firm employees who are well-known and respected, i.e. trusted, will have a higher ability to influence the community activities, than firm employees who are less well-connected (Dahlander & Magnusson, 2005). The rich possibilities for firm employees to gain lateral authority, by making strong efforts and spanning boundaries, is thus linked to the possibility of having influence, since the underlying enabling element for both is the governance mechanism of do-ocracy. Indeed, to tie it all together, findings indicate that higher levels of engagement and activity, can lead to more social ties, which can improve reputation and trust, which in turn can strengthen the ability to influence community work through lateral authority.

However, it is important to make a distinction between influence on the project level and influence on the organizational level. While the above analysis found possibilities to influence project work, empirical findings also show that influence on the organizational level is limited or even non-existent. Makerspaces are characterized as volatile, they have varying participation and they are organically driven (Figure 7). At the organizational level, BG does not have a specific direction or path that is has to follow (MMBO, 2015). Everything is open, and what happens is the result of the work of dynamic groups (MMBO, 2015). To influence the makerspace as a whole in some direction thus seems nearly impossible, even undesirable, as it would require a large amount of resources just to make the effort.

To sum up, the above analysis shows support for Proposition 2.b, although influence is more likely on the project level.

Proposition 2.b: Firm employees can build trust and gain influence by making strong technical, communication and coordination efforts, and thus increase the possibility for the firm to influence community work towards valuable agendas.

6.2.3 Adaptive Governance

On the issue of 'adaptive governance' (Spaeth, et al., 2010:424), 'Independence' (O'Mahony, 2007:144) will be delved into first, by analyzing the impact of eschewing the use of contracts in firm-makerspace collaboration. An analysis of the importance and impact of a model of 'decentralized decision-making' (ibid:147) will follow. Finally, the analysis will focus on how governance and organization can allow for 'Autonomous participation' (ibid:148) in order to elicit suggestions from a broad spectrum of makerspace participants.

In the Baessy project, there were no contracts or formal agreements made. Instead, the NZ employee signed up for a regular membership to BG and participated as any other member would (MMBO, 2015). Thus, the employee was on equal footing with makerspace participants (GEAB, 2015) and obtained no status or authority through employment at NZ, but only through performing work on the project (MMBO, 2015) as is characteristic of makerspaces (Kostakis, et al., 2014). The involved makerspace participants from BG insisted upon this arrangement of no contracts and equal membership (CBXT, 2015), as *"legally, BiologiGaragen is an association, but their statutes mandate, that two people cannot make a binding agreement that covers anyone but themselves."* (JAWE, 2015:00:02:29). Thus, no single person could enforce his or her will upon another through any claim to authority (MMBO, 2015), which satisfies the criteria of 'independence from authority structures rooted in employment relations' (O'Mahony, 2007:145). These findings of how to maintain independence of the makerspace through adapting governance to accommodate for makerspace participants' desires seem fairly straightforward. However, the practice of working with non-contractual agreements is highly foreign to an R&D intensive firm, such as NZ (MKBS, 2015).

While avoiding contracts enables the freedom of makerspace participants, it poses certain challenges for the firm. First, there is the governance issue of the firm having no authority to 'police' (Piller & West, 2014:45) the project, which increases uncertainty about value creation, as the firm cannot control the direction of the project. Instead, the practice of subtle control through contribution must be enacted. Second, the absence of contracts can become a mental barrier for employees. The practice is highly unusual, as contracts are an ingrained part of NZ' collaboration model (MKBS, 2015), to the point that the idea of working without these can be daunting for NZ employees: *"It [the idea of working without contracts] is so challenging, that I have a hard time grasping it. Let me say it frankly: from the outset,* *even mentioning your research purpose must be done with a lot of consideration […]"* (HANS, 2015:00:10:55). This quote highlights not only the mental barrier of working without contracts, but also how NZ employees perceive being constrained in their freedom to use their specific knowledge, for fear of leaking protected firm knowledge out into the open. Indeed, several NZ employees were uncertain about, what information they could share openly, as it can be difficult to make the distinction between personal knowledge and knowledge core to the firm. (JEEQ, 2015; MKBS, 2015).

The perceived consequences of working without contracts were a recurring theme among NZ employees interviewed as reflected in the concept of 'IPR and contract issues' (Figure 2). This was often related to the concern over IPR: *"Who owns what? Who can file patents? My world is contracts. We can talk to customers and partners without them, but if it is to be anything serious, there has to be paper on it. It is unavoidable."* (MTFR, 2015:00:08:41). Thus, Piller & West's (2014) key collaborating activity of 'Openness of firm attitudes, structures and processes' (Piller & West, 2014:40) becomes an issue, in that employees can be wary of firm-makerspace collaboration. However, this concern may be alleviated through experience with such collaboration. In the Baessy project, the area of focus was non-core to NZ, and the issue of IPR was completely avoided (GEAB, 2015). Accordingly, concerns over IPR and contracts were not present among the NZ employees who had been part of the Baessy project, although they found it challenging to understand the open work processes (CBXT, 2015; GEAB, 2015) and they were initially uncertain of how to proceed without contracts (CBXT, 2015).

While working in non-core areas serves to alleviate the concern over lack of contracts and IPR, it creates an issue regarding whether NZ employees perceive collaboration to have commercial value (Figure 2). Those NZ employees who have been involved in the project focused on the future insights (GEAB, 2015), mindset & culture benefits (FHAT, 2015), as well as how collaboration could help the firm avoid being disrupted (CBXT, 2015). *"The challenge lies in realizing and recognizing that here we have a completely new strategic game opening up which requires a new mindset and culture, or new attributes in our innovation culture."* (FHAT, 2015:00:35:12). However, with the firm innovation process being driven by market needs (Table 3), the focus of NZ employees not yet involved in a makerspace project was on how there was yet a 'Limited proof of concept' (Figure 2) to showcase the commercial value of such endeavors: *"So you are saying IPR over the invention will be lost? Are there any contracts stipulating that you cannot take up patents? That sounds wildly naïve, but cool I guess!*

When the ethanol sensor is brought to market, who will profit from it? What do Novozymes get out of it?" (MTFR, 2015:00:04:17). Thus, while independence is ensured through abolishing contracts, which caters to the values of openness in makerspaces (Figure 7), the challenge of proving the value of firm-makerspace collaboration to employees arises instead.

Governance that allows for 'decentralized decision-making' (O'Mahony, 2007:147) distributes decision-rights to members of the community. This is linked to the discussion of eschewing contracts, as they would be a formal way to ensure centralized control. To makerspace participants, it was important that firms cede control of projects and keep them open (Figure 5). NZ employees agreed with this sentiment, but their focus was to a higher degree on 'Avoiding IPR issues', by keeping the collaboration process open and not attempting to protect the created knowledge, as discussed above. The decision-making structure of the Baessy project was relatively flat (MMBO, 2015) and in line with makerspace principles of being organically driven and open (Figure 7). Decisions about the project were made by those involved, and with no oversight from NZ once the process had begun (CBXT, 2015), except from the initial executive decision that there should be no work done within the core areas of NZ (CBXT, 2015). A makerspace participant and a NZ employee became the hub of the project, leading it through their own contributions. Inputs were accepted, as people from the makerspace joined in and made various contributions from brainstorming to individual elements on the project (MMBO, 2015; GEAB, 2015). Thus, central control was relinquished in order to let collaborators move the project in a desired direction. This meant that a great deal of responsibility and autonomy was thrust upon the employee to work in a way he saw fit (CBXT, 2015).
Thus, a project environment was created, which maintained the tenets of a do-ocracy, namely that decisions were ultimately made by those who acted and took upon them lateral authority. This method of 'organizing' (Piller & West, 2014:40) the project is rooted in the processes of coordination and subtle control rather than overt governance structure. Thus, organizing and governing firm-makerspace collaboration do not happen through firms stipulating how a project should be carried out, but through their employees contributing and influencing projects from within, as found in section 6.2.2.
While governance characterized by decentralized decision-making is important to firm-makerspace relations, it gives rise to new issues. When firms cede control, they can have no final say in the direction of the project and thus cannot prevent it from moving away from firm goals (ibid:45) or

splitting into multiple subprojects (Fleming & Waguespack, 2007). However, those who assume lateral authority become the ones who make final decisions (EMPO, 2015). Thus, control through governance can to some extent be substituted by lateral authority.

One of the main tenets of BG is that everyone can participate in a way that works for them, which corresponds to 'Autonomous participation' (O'Mahony, 2007:148): *"Everyone are there as individuals and contribute with the knowledge they have, in relation to their engagement or the time they spend."* (MMBO, 2015:00:16:56). However, there are certain expectations of contribution and makerspace participants are attempting to install some sort of minimum requirements for participating (EMPO, 2015). While the high degree of 'Varying participation' (Figure 7) is generally seen as a positive trait (MMBO, 2015), it can also create some tension as some participants may be viewed as *"leeches"* (SSØR, 2015:00:58:41). If a person asks a question, he or she will be expected to have made some initial effort towards solving it, rather than just asking others to do it for them – this applies to both individuals and firms (NNIS, 2015; SSØR, 2015). This can be an obstacle for newcomers: *"It is a place, where a certain level is expected, when you arrive. A lot of people have had a really big problem with this, when they show up the first time, because they are used to, as Danes, being able to show up and then something happens that you can participate in. That doesn't happen down there. If you don't take an initiative and don't start something yourself, you shouldn't expect much happening."* (SSØR, 2015:00:05:41). However, efforts are made to include everyone who show genuine interest and effort. Members are then willing to answer questions (NNIS, 2015) and try to make projects appear accessible to newcomers (MMBO, 2015).
This is indicated by the efforts made to allow for autonomous participation, as explained by a makerspace participant: *"All ideas are open all the time. This transparency ensures that everything is thrown around blogs and mailing lists all the time. You throw in your two cents where you want and you drive a project where you want."* (MMBO, 2015:00:29:18). Transparency is thus a keyword; by sharing information on mailing lists, wiki's, blogs and even live chatting during events, the makerspace participants attempt to ensure that everyone can participate in and learn from projects (MMBO, 2015). This means that everyone can contribute, even if they cannot appear physically in the makerspace. When contributing to a project, the rules are that anyone can do as they please, as long as the process is easily reversible in case something goes wrong, but for more impactful decisions, those who are central

project coordinators should be consulted (GEAB, 2015). Thus, there is a potential for project coordinators to discourage initiatives but consensus rules for larger decisions. As BG is an open organization with a flat structure (Figure 7), there is plenty of room for healthy discussion, with inputs coming in both online and offline (EMPO, 2015). This was mirrored in the Baessy project, where other makerspace participants contributed in brainstorming and creating 3-D models for the project (MMBO, 2015). There is, however, a potential for projects splitting into several directions, if consensus cannot be reached.
Autonomous participation, then, was relatively unhindered by the governance of the Baessy project, as the rules in place, in principle, allowed anyone to contribute. Technically, contributing was also made feasible by knowledge sharing and utilization of social media.

In summary, NZ pursued an adaptive model of governance, which allowed for independence, decentralized decision-making and autonomous participation, by abandoning the usual, more structured and controlled, model of governing collaborations. This approach was important to makerspace participants and enabled contributions from several participants. Thus, support was found for Proposition 2.c.

Proposition 2.c Firm-makerspace collaboration should be characterized by adaptive governance that supports Independence, Decentralized decision-making and Autonomous participation.

In addition, it was found that abolishing the use of contracts led to issues of employee reluctance, as they were uncertain about value of collaboration and what knowledge they were allowed to share. Additionally, it led to a lack of control of the collaboration process.

6.2.4 Conclusion of Analysis Part 2

The findings from the analysis support the notions from theory, that consistent contributions from firm employees, following the norms of reciprocity, were motivating to makerspace participants. Interviewees noted that the contributive context should be one in which firm employees and makerspace participants worked together as individuals and peers. This symbiotic approach was found to be motivating, while the commensalistic approach of trying to gain knowledge without contributing was demotivating. Thus, Proposition 2.a was supported.

Continuous commitment also served to alleviate concerns over firm intentions among makerspace participants, as trust was found to be built through coordination, communication and technical efforts from firm employees. Employees have opportunities to mobilize support, through initiating projects and communicating about them, and in doing so assume lateral authority. Employees can dedicate more time than makerspace participants to strengthen ties in the makerspace and thus increase their social capital through spanning boundaries between groups. These efforts of building trust and social capital through continuous commitment may also allow firm employees to influence the direction the project takes, without having formal control over it.
Thus Proposition 2.b was supported, but influence was found to be limited to project level only.

According to the analysis, NZ adapted a loose model of governance, in order to suit makerspace characteristics, which allowed for independence, decentralized decision-making and autonomous participation. NZ relinquished the use of contracts in the firm-makerspace collaboration in order to maintain the independence of the project, thus putting employees on equal footing with makerspace participants in terms of decision-making. The decision making structure was flat, and NZ ceded control of the process, allowing for decentralized decision-making.
The project was made easy to access for any contributors, through maintaining high accessibility on both technical and organizational parameters. Autonomous participation was thus enabled through clear work processes, extensive use of information sharing and an openness to receiving inputs.
The analysis of governance thus supported Proposition 2.c. However, the issue of abolishing contracts gave rise to challenges regarding reluctance of NZ employees to enter a radically different collaboration process because of uncertainty about the value of such efforts. Furthermore, as overt control of the process is relinquished, the firm cannot control who contributes and what the final outcomes will be, adding to the uncertainty over the value of firm-makerspace collaboration.

The propositions together provide an answer to sub-question 2: *How should firm-makerspace collaboration be organized and governed*? The collaboration should be organized through individual relations, where continuous commitment from firm employees maintains relations, builds trust and enables firm employees to influence the projects. Formal governance should be kept to a minimum and adapted to makerspace characteristics in order to enable and encourage contributions from makerspace participants.

6.3 Analysis Part 3 - How can Firm-Makerspace Collaboration affect the Firm's Ability to alter its Resource Base in a Dynamic Capability Perspective?

Having investigated motivational, organizational and governance aspects of firm-makerspace collaboration, the effect of such collaborations on the firm's ability to alter its resource base will be studied in this section. As such, this section will focus on the last stage of the process model for ICOI. In this stage, the focus is on how firms can benefit from and leverage this type of OI (Piller & West, 2014).

6.3.1 Bodies of Understanding, Bodies of Practice and Integrative Competencies

As described in the theoretical framework, bodies of understanding reflect the qualifications in specific technological fields or general domains of knowledge and are often related to fundamental disciplines. Bodies of practice are related to the selection and integration of different pieces of knowledge, bodies of understanding, in the context of their application and are thus context-specific knowledge (Nesta & Dibiaggio, 2003). A firm's bodies of practice are often obtained through a combination of experimentation, experience, information and knowledge sharing. The two types of bodies of knowledge are complementary elements, since a body of practice largely consists of organizational knowledge that connects bodies of understanding with commercially useful applications (Pavitt, 1998). In their study of the sources of firms' technological differentiation in biotechnology-related industries, Nesta & Dibiaggio (2003) found that over time firms tend to have similar bodies of understanding, as they widen their knowledge base, but showed an increasing divergence in their bodies of practice (Nesta & Dibiaggio, 2003). Competitiveness, then, has more to do with finding and developing new technological combinations to exploit complementarities between bodies of understanding, rather than technological leadership in given scientific areas (ibid). Interviews with NZ employees indicated support for this finding. Often, the difference resides in the knowledge of how to combine different technologies more than in the IPR obtained in specific areas, and this is why firms are very secretive about their specific processes (GIBU, 2015). In addition, there was a recognition of the fact that external actors around the world, such as small firms and startups, may match NZ' technological capabilities in many disciplines, and that *"[…] the strength is found, not in the individual disciplines mastered by the firm, although they are of course important, but in the system. The strength lies in everything you have, the way you combine it, the way you manage it, the way you integrate it into the*

business" (HANS, 2015:00:06:39). What the interviewees are referring to, can be characterized as the firm's bodies of practice, which then become an important competitive competence. This notion corresponds with the findings of Christensen (2006), that large R&D intensive firms no longer can rely on a few deep core competencies, and that integrative competencies are becoming increasingly important (Christensen, 2006). As the global technology base is expanding at a high rate, firms should recognize that an increasing share of relevant technological knowledge is created externally (ibid). Although core competencies are still needed, the risk of them turning in to core rigidities has become increasingly prevalent, as technology and knowledge expand more rapidly externally than internally (ibid). Deloitte's Center for the Edge provides some useful empirical insights on the long-term changes that are happening in the world. Today, knowledge is more rich, diverse, and accessible, in ways that were not possible before. This in turn increases uncertainty, as new innovations often appear from unexpected places, and accelerates change (Hagel, 2015a). This effect has demanded attention from firms as they look to other industries that have been disrupted (CBXT, 2015). In the category 'Uncertainty about the future', the concept 'Threat of disruption' was clearly expressed in interviews with NZ employees (Table 3). Head of Innovation Development at NZ stated that the disruptive threat has increased significantly: *"[…] if we don't act, we might become the next taxi industry, or the next industry that has to deal with issues of disruptive threats and unforeseen developments. […] there is an entirely different urgency today than there was five years ago*" (FHAT, 2015:00:42:30). In a similar vein, NZ' Vice President of Biotechnology Research recognized how the internet has opened the world, enabling everyone to use their competences wherever they are, and that this may bring significant changes: "*I believe that the change will be big, and we dare not be left out*." (EJBJ, 2015:00:17:31). This indicates how the increasing uncertainty and accelerating rate of change challenge firms, as they feel an urgency to act although under great uncertainty.
Building capabilities to become more resilient and able to respond to changing environments, thus seem increasingly important.

The notion of the decreasing role of core competencies and the increasing importance of integrative competencies (Christensen, 2006), is supported by Deloitte's Center for the Edge. They highlight the shift from the traditional closed way of operating, which focuses on developing, protecting and extracting value from proprietary knowledge stocks, to a new more open way of operating, which focusing on collaboration and participation in knowledge flows to learn faster and refresh knowledge stocks at an accelerating rate (Hagel, 2015a). The opportunity for firms, then, is to learn how to aggregate and connect knowledge flows (Hagel, 2015b). The parallels between knowledge stocks and bodies of understanding, and between knowledge flows and bodies of practice, hence integrative competencies, are thus profound.

Empirical research, including data from the interviews with NZ employees, thus support the importance of integrative competencies. Integrative competencies include capacities for "*systems integration and for reconfiguring and building internal and external capabilities to address changing environments*." (Christensen, 2006:36). One key feature of integrative competencies is then the firm's dynamic capabilities (Christensen, 2006). In the following section, NZ' attempts to build the necessary capabilities to innovate in a rapidly changing world, by engaging in firm-makerspace collaboration, will be analyzed through a dynamic capabilities perspective.

6.3.2 Leveraging Existing Resources

One mode of dynamic capabilities is to leverage existing resources by putting them to new uses (Eisenhardt & Martin, 2000; Danneels, 2010; Teece, et al., 1997). One type of resources can be human assets including local abilities and competencies (Eisenhardt & Martin, 2000). In the Baessy project, NZ leveraged one of their human assets by sending him out to work in BG: *"[…] R&D decided to invest resources in it by sending one of the best technology developers out to spend time in BiologiGaragen*" (FHAT, 2015:00:02:15). He brought along with him insights and experience from the firm's knowledge base, although he clearly stated that the collaboration could not revolve around NZ' end products, but around supporting technological processes instead (GEAB, 2015). This indicates a carefulness to protect knowledge within the core-area of the business, which was also indicated in the interviews where 'Should not involve core areas of the firm' was by far the most frequently mentioned concept by NZ employees in the category of 'Defining projects' (Figure 3). As discussed in section 6.2.3, this was a consequence of eschewing contracts, along with the open approach taken by makerspaces, resulting in an inability to enforce IPR. Working in a non-core area thus became a mechanism to avoid IPR issues altogether.

The employee had a lot to offer in the makerspace collaboration, and was thus valued by the makerspace participants. One participant stated that the employee was a highly skilled researcher with a lot of knowledge gained from working in NZ, which the makerspace could benefit from (EMPO, 2015). Thus, the human capital embodied in the employee was a fungible resource, which is a resource that is amenable to multiple applications (Danneels, 2010). However, it was also clear from interviews with NZ employees that this kind of open collaboration was not for everyone. Not only are certain characteristics and competencies required to benefit from this type of collaboration, but some NZ employees also lack the desire to work in such environments (EJBJ, 2015; MKBS, 2015; JEEQ, 2015). Thus, management should carefully consider which employees would be suitable for firm-makerspace collaboration. The challenge of selecting the right employees relates to the concept of 'resource cognition', which is the management's comprehension of the firm's resources and their fungibility (Danneels, 2010:21). Since NZ is in the very early stages of exploring collaborations with makerspaces, one could argue that resource cognition needs to develop over time and with experience. One NZ employee argued that management would have a hard time judging, which employees would be best suited for such tasks, and instead suggested that employees self-select for firm-makerspace collaboration (JEEQ, 2015). Indeed, such a practice would provide an interesting avenue for building resource cognition in the context of leveraging human resources.

By leveraging human assets through dedicating employees to work on projects in makerspaces, which is in accordance with the approach outlined in section 6.2.1, NZ is building a bridge to the world of makerspaces and their networks. According to Rothaermel & Hess (2007), 'Star Scientists', highly skilled and influential researchers within their field, often assume boundary spanning roles, which are critical functions in a firm's ability to innovate (Rothaermel & Hess, 2007:900). Boundary spanners are bridging organizational and environmental boundaries to facilitate the firm's ability to collect, evaluate and apply external knowledge flows through a two-step process: "*They are able to gather and understand external information and then translate and disseminate this information into terms that are meaningful and useful to other organization members*." (ibid). The NZ employee, being one of the firm's most skillful technology developers (FHAT, 2015), can be characterized as star scientist. In addition, interview responses indicate that he was indeed assuming the role as a boundary spanner. In the Baessy project, the employee acted as the touchpoint to BG and tried to restructure findings from the project, and the experiments, into something familiar when reporting back to NZ (CBXT, 2015). It has been found that the primary role of star scientists is to help cue the firm towards potential shifts in the environment and promising new areas of research, rather than to facilitate the firm's specific adaptation to changes, which is more often accomplished by a large number of 'non-star Scientists' (Rothaermel & Hess, 2007:915). In the category 'Knowledge benefits', the concepts of 'Future insights', 'New areas of knowledge' and 'Spotting trends early' were mentioned frequently (Figure 6). In addition, the creative strength of the free knowledge flows in makerspaces was recognized by several NZ employees (Figure 7). One of the business developers expressed it very clearly: "*Makerspaces are a really good indicator of where the technology of the future is going. It is prototypes made from the technology we have at our disposal today, but the thinking behind it, is much further ahead [...] it is something you can only find out in the totally open space, where creativity is allowed to unfold*" (CBXT, 2015:00:08:38). Thus, findings indicate the potential for firm employees to spot both potential shifts and new research areas when engaging in makerspace collaborations.

Leveraging existing human capital by selecting the right employees to participate in makerspace collaborations, take the role of boundary spanners and help the firm collect and filter external information, can thus be argued to enhance the firm's ability to leverage external knowledge flows, hence the capability to address environmental changes.

6.3.3 Accessing New Resources Externally

Leveraging existing resources in new ways is one way to exert dynamic capability. In the case of the Baessy project, it was also a gateway to another mode of dynamic capability, namely accessing new resources externally (Eisenhardt & Martin, 2000; Danneels, 2010; Teece, et al., 1997). Based on the findings in analysis part 1 and 2, leveraging existing resources in new ways is arguably more than a gateway to access new resources externally. Indeed, it could be a prerequisite for accessing resources in makerspaces, as active participation from firm employees, was found essential to building a fruitful relation. Simply trying to leverage resources in makerspaces and their networks from an outside position, would arguably violate the premise of reciprocity and be hampered by the suspicious attitudes towards firm intentions.

6.3.3.1 Interdisciplinarity

In makerspaces the diversity and interdisciplinarity are high (Figure 7), and the strength of their workforce was indicated in the interviews, where 'Many contributors' and a 'Global network' were mentioned as important 'Network benefits' (Figure 9). Many participants are highly skilled or even experts within their fields (SSØR, 2015; MIAL, 2015; CBXT, 2015). These people possess specific technological knowledge, bodies of understanding, and when coming together in an interdisciplinary community, they discover new ways to combine and use their knowledge, bodies of practice: "*Any interdisciplinary exchange of information, experiences and ideas between people with different backgrounds creates new knowledge and empowers you with more knowledge*" (MIAL, 2015:00:15:16). Further, the makerspace participants are trying to cover the interdisciplinary gap, and when holding event meetings there are often fifteen people with different backgrounds (MIAL, 2015). These interactions give rise to innovative projects: "*When people get together they are talking about things they are passionate about, we are talking about people who have tons of ideas, they are very creative and they take time to think of that. […] they are not going to discuss the weather or politics. They will discuss things that will probably happen two months into the future, they will probably get together and do something together.*" (MIAL, 2015:00:42:03). Indeed, as another participant stated: "*[…] there is a general tendency that the best project groups are formed when mixing people with diverse backgrounds, who can supplement each other in great ways.*" (EMPO, 2015:00:39:57). Accordingly, the concepts 'New areas of knowledge' and 'Interdisciplinary areas of knowledge' were frequently mentioned in the category 'Knowledge benefits' (Figure 6). One of the strengths of makerspaces is thus the interdisciplinarity (EMPO, 2015), a strength which NZ lacks internally (MKBS, 2015; JEEQ, 2015; MTFR, 2015). 'Internal homogeneity' was a concept that emerged in interviews with NZ employees (Table 3) and Vice President of Biotechnology Research at NZ has acknowledged that the scientists at NZ, although being very skilled, are similar and often think alike, since they work in an environment that breeds a certain methodology of thinking (Hansted & Carlsen, 2015). By having similar backgrounds within biology, NZ employees tend to stick to conventional thinking when finding solutions, and this tendency sometimes needs to be challenged to stir up creativity and innovation (MKBS, 2015; MTFR, 2015). This is moreover a tendency that firms in general may suffer from (EMPO, 2015; MIAL, 2015). As employees' knowledge bases are similar, the absorptive capacity of the firm will not apply to as wide a range of disciplines as may be necessary for exploring new knowledge, as absorptive capacity applies only to related areas of knowledge (Cohen & Levinthal, 1990). Exposure to diverse areas of knowledge can then improve the absorptive capacity of the firm (Zahra & George, 2002) through makerspace collaborations.

In the Baessy project, the employee and the other central project participant learned about open source micro-electronics and hardware, from other members in Labitat proficient in that area (EMPO, 2015; GEAB, 2015). The prototype in itself, however, was not the most valuable outcome of the collaboration, it was more a symbol of the success of the collaboration. The process of creating it and the learning experiences along the way, were a big part of the value (GEAB, 2015). It was a proof of concept, that one could use makerspace collaborations to develop something by combining technology fields that NZ normally do not know much about (EJBJ, 2015), which indicates how the integrative competencies of NZ may benefit from firm-makerspace collaborations. The empirical case, then, shows how combining different technology fields, through people with different backgrounds, results in new technology and ideas for application – in other words, new bodies of practice are developed.

6.3.3.2 Freedom to Fail and Create

Further improving and facilitating the creation of new bodies of practice in the makerspace environment is the inherent freedom to be creative and to fail in makerspaces. While firms have business plans, milestones to be achieved within a given time frame and investors to satisfy, the open communities have a different approach to solving challenges (Hansted & Carlsen, 2015). The makerspace environment does not fit into a stage-gate model, the projects would most likely not survive even the first gate, and therefore it entails the freedom to experiment with new projects without having to reach any milestones (CBXT, 2015). Additionally, the solutions developed in the communities can be totally different, as they bring together both amateurs and professionals from different fields (Hansted & Carlsen, 2015; EMPO, 2015). This environment is in contrast to the internal working environment at NZ. Internally, a project follows a streamlined project plan, and if it fails it will close down, but makerspaces have a more dynamic approach, and they do not have to close down the project because the result does not fit a customer's requirements (CBXT, 2015). This also means that they have the possibility to change the project or the product along the way, and maybe end up with an unforeseen innovation. The possibilities for this type of accidental innovation are very slim internally in NZ (CBXT, 2015).

The above indicates the strength of an environment, where failure is embraced and encouraged. Failure or negative results matter as much as positive results, because there is a huge learning benefit from it (MIAL, 2015). There is a belief that it does not create good research, when researchers do not publish the failures they encounter, because others may then have to make the same mistakes, which is a waste of time and resources (EMPO, 2015). Furthermore, in the open communities a tremendous amount of people can try and fail, and only one of them needs to be right, which is a really powerful mechanism (Hansted & Carlsen, 2015). In these networks, people have less filters and can think more freely than employees in NZ (EJBJ, 2015), which arguably, to a large degree, is empowered by the unconstrained freedom to be both creative and to fail. One employee described the general responses very accurately with this metaphor of a square confine: *"If I should think about what confines us as soon as we start something up of any kind, then it is a mix of the following; we have to settle on some IPR issues, we have a partner, that preferably should gain a huge impact [...], and then we have an internal bureaucracy to take into account. If you imagine this as a square, there is only one free flank to do the thinking. So, if one could break free from some of these built in tribulations, then one could may get a lot further."* (GIBU, 2015:00:10:12). Access to working with the people and projects in the makerspace environments, can thus facilitate unlocking more "flanks" in the square to think more freely and allow creative experimentation without worrying too much about the consequences of failure. This can in turn help develop the firm's dynamic capabilities, as mistakes and failure play an important role in their evolution (Eisenhardt & Martin, 2000).

Through experimentation, learning by doing and freedom to be creative, new bodies of practice are arguably created in makerspaces. While bodies of understanding are easy to articulate and generalize, thus relatively easy to transfer between organizations, bodies of practice are context-specific knowledge, highly dependent on experience and skills, developed in the course of projects, and are thus hard to codify and transfer (Nesta & Dibiaggio, 2003). Supportively, the Director of Food and Beverage in R&D at NZ stated that actively participating and being part of the process and learning from it, is what really matters, since information about general topics can often simply be found on the internet (FIOD, 2015). 'Network access' was mentioned as a benefit (Figure 9), but if the firm simply observes and passively follows the developments in makerspaces, they may only be able to identify bodies of understanding. This underlines the importance of the approach proposed in analysis part 2, having firm employees actively participating in makerspace projects, to leverage knowledge and learn about potential new bodies of practice.

Based on the analyses above, firms can tap into and learn from a large external pool of diverse human capital through collaboration with makerspaces. As more projects are carried out, the firm's capability to access these resources externally will arguably develop accordingly, since repeated practice is an important learning mechanism for the development of dynamic capabilities (Eisenhardt & Martin, 2000). An important question remains however, about how NZ may create new resources and competencies internally - a third mode of exerting dynamic capability (Danneels, 2010; Eisenhardt & Martin, 2000; Teece, et al., 1997).

6.3.4 Creating New Resources

In the empirical case, the distinction between the two modes of exerting dynamic capabilities, accessing external resources and creating new ones internally, is fairly blurred. While the project and the process are taking place outside the firm, the employee participating is arguably developing his mindset, skills and knowledge base, which in turn may enable the firm to build new resources internally by integrating and applying knowledge from the employee. Moreover, since the employee himself is an internal resource, one could argue that in the process of accessing external resources in makerspaces, new competencies are developed internally as the employee expands his knowledge base and reports back to the firm. The first type of resource that is created from engaging in collaborations with makerspaces is thus arguably the new competencies, skills and knowledge of the participating firm employees. However, whether NZ succeeded in the configuration of the expanded knowledge pool into new company-wide competencies, was not indicated in the empirical data.

From the empirical findings, there was scarce evidence that new resources or competencies had actually been developed internally as a result of the Baessy project. This may be a result of the novelty of the practice, as NZ are still experimenting and trying to build a business case around firm-makerspace collaboration (CBXT, 2015), and developing new resources takes time and repetitive efforts. In the long term, NZ aim at integrating the practice as a more substantial part of their innovation processes and create an internal network of employees with experience from firm-makerspace collaborations (EJBJ, 2015). 'Strategic integration' was also mentioned in interviews as an important element (Table 3). Thus, this is arguably an indication of the first step in how new company-wide competencies could be created.

At the same time, 'IPR & contract issues' and 'Prioritization of scarce resources' were the two most frequently mentioned concepts, in the category 'Barriers & challenges to collaboration', by NZ employees (Figure 2). 'Value creation' was an important consideration in the category 'Strategic approach' (Table 3), as there has to be people in the firm who believe in firm-makerspace collaboration, and this is most easily achieved by demonstrating the value of it on several occasions (EJBJ, 2015). There is thus a need to show that this very new and different type of collaboration can create value and make a difference, and this is not something that can be achieved quickly (EJBJ, 2015; CBXT, 2015). This could mitigate the perception found among NZ employees, that the commercial value of firm-makerspace collaboration was not clear (Figure 2). In time, however, firm-makerspace collaborations are likely to become an essential part of many processes in the firm (EJBJ, 2015). However, *"The challenge is to realize and acknowledge that it is a new strategic game that is emerging, which requires a new mindset, a new culture or some new attributes of the innovation culture in the firm."* (FHAT, 2015:00:35:25). It also requires new competencies because leveraging engagement in open environments, the possibilities for structured foresighting and trend research, is dependent on skillsets. It requires relatively structured learning activities, which employees learn from and then have to pass on to other employees and train them (FHAT, 2015). The question is how to embed these capabilities in the organization and as part of the value creation process in the firm (FHAT, 2015). Nevertheless, the potential for future development of new internal competencies were indeed highlighted by NZ employees. Four main areas were mentioned, 1) development of a new mindset and dimension in the culture, 2) adding new elements to customer solutions, 3) new processes for R&D and 4) developing the firm's ability to address environmental changes including the ability to face disruption. The next three sections will investigate these areas.

6.3.4.1 New Mindset and Cultural Dimension

In interviews with NZ employees, 'Mindset & culture benefit from openness' was by far the most frequently mentioned concept in the category 'Organizational benefits' (Figure 10). This is arguably connected to the concept 'Relatively closed tradition and culture' that emerged in the category 'Firm characteristics' (Table 3). Traditionally NZ has had every discipline needed to develop new enzymes in-house. The firm has therefore not been raised with a culture, where it is necessary to reach out for solutions, and the external openness in the firm has primarily been on a business-to-business basis (HANS, 2015; MKBS, 2015). Thus, prior success has created an introvert locus of search and reaching out for external experts is not the norm. Being more externally oriented in the approach to problem-solving and finding solutions is thus something the firm culture and the mindset of employees could benefit from (HANS, 2015; MKBS, 2015; GIBU, 2015). Successful external collaboration with makerspaces could guide firm employees unto new paths through exposure to abstract and practical knowledge and encountering new information gathering processes. It would provoke new ways of thinking, which would be beneficial for many employees (GIBU, 2015; MTFR, 2015). As absorptive capacity is highly path dependent, both in terms of prior knowledge and organizational mindset, changing these patterns is a continuous process (Zahra & George, 2002). This process can arguably be facilitated through collaboration with makerspaces. One senior manager stated: "*I think part of the value lies in the cultural area, that both the persons who have participated and the persons that have seen others do it, when they themselves encounter some problem that can't be solved within the their normal [tool] box, then the mentality and attitude towards solving the problem will automatically be more extrovert*." (HANS, 2015:00:47:52). The extension of the repertoire for finding solutions can indeed be a strong incentive to open up the organization more (HANS, 2015).

While improving the firm's ability to acquire external knowledge expands the knowledge pool available to the firm, it remains crucial to transform this knowledge into useful innovation. Transferring acquired knowledge to where it can be used is a challenge both for those insights gained through the Baessy project (CBXT, 2015), but also NZ at large: *"It's not always trivial here. I mean we have systems for knowledge sharing, but it is not always finding the person that needs that knowledge. And of course everyone can't read everything. We have to sort of know people essentially to get the knowledge to them."* (JEEQ, 2015:00:16:13). It is an issue, that while there are formal information sharing systems in place (Table 3), there is not a strong culture of utilizing them across the organization (FIOD, 2015; JEEQ, 2015). In makerspaces there are synergies between face-to-face contact and online systems for knowledge sharing that allows anyone to self-select for providing input to a process, which is a powerful tool for transferring knowledge to an area of application. This helps facilitate transfer of knowledge from analogous fields, which is a strong method for coming up with novel solutions (Poetz & Prügl, 2010), which is otherwise difficult to achieve. Holders of knowledge may not be aware of where it can be used, while those confronted with technical challenges are unaware that solutions might in fact reside in these analogous fields.

Implementing a practice of knowledge transfer is a process that can be difficult to enforce, as showcased by the difficulties with the current formal system in NZ. Rather, employees must be shown the benefits of this knowledge transfer method through experiencing collaboration first-hand or being continually presented with benefits from this new way of doing things (GEAB, 2015; CBXT, 2015). This does not necessarily entail developing new systems for knowledge sharing, but rather creating an internal mindset of using the tools already available for knowledge sharing. This mindset cannot be imposed, but can arguably be encouraged through experiencing the benefits of cross-fertilizing ideas through collaborations with makerspaces.

6.3.4.2 Improving Customer Solutions and New Processes for R&D

'Knowledge of complementary technologies & services' and 'Absorbing new inputs' were frequently mentioned concepts in the category 'Knowledge benefits' (Figure 6), while 'Faster innovation' was mentioned in the category 'Organizational benefits' (Figure 10). These concepts relate to both the development of better customer solutions and new processes for experimentation. First, NZ often deliver not only the enzyme, but also services around the use of the product, a kind of "package solution", which is highly valuable to customers (MKBS, 2015; HANS, 2015). Here, knowledge about the complementary technologies and services underlying the efficient, safe and appropriate use of the enzyme can be developed in firm-makerspace collaboration (CBXT, 2015; HANS, 2015; FIOD, 2015). As makerspace participants are creative and possess a wide array of skills (Figure 7), they can help bring perspective to invention. The knowledge of the participants can solve composite problems (Hansted & Carlsen, 2015), through their combined knowledge of how changing one component has wider implications at the systems architecture level. Thus, engaging with makerspaces may not necessarily lead to innovation specific to NZ' primary products, but could provide knowledge of the wider context in which they are applied, and thereby help NZ provide holistic solutions to customers. Second, knowledge about complementary technology, such as the ethanol sensor from the Baessy project, and new inputs (Figure 6), may enable NZ to develop new or improve existing processes for experiments and testing, potentially reducing costs and improving efficiency (GIBU, 2015; FHAT, 2015; FIOD, 2015), which is reflected in the concept of 'New opportunities for R&D' (Figure 9). As makerspace participants often work with basic "kitchen table" resources, they device creative ways of working around issues, that would otherwise be solved with advanced and expensive equipment (JAWE, 2015). This DIY attitude can be important to learn from, as it teaches creativity in workaround solutions, which could be transferred to internal process improvement. In general, NZ are very focused on enzymes but not very good at looking at all the technology that surrounds their own technology (CBXT, 2015). Engaging in firm-makerspace collaborations may then help the firm to spot or even develop new complementary technology.

6.3.4.3 Improving Resilience and the Ability to Face Disruption

As outlined in section 6.3.1, there is an increasing urgency to address disruptive threats in the rapidly changing environment. It is difficult for NZ to be sure that they understand what the next generation of technology will be, but they are certain that they have to be ready for the best and newest technology in order to survive (EJBJ, 2015). The concepts of 'Future insights', 'New areas of knowledge', 'Spotting trends early' and 'Better prepared to face disruption' made up a large amount of the concepts in the category 'Knowledge benefits' (Figure 6). More specifically, engagement in open communities, such as makerspaces, creates better insights about future technology and is thus a kind of future foresight (FHAT, 2015). It enables one to understand trends much faster by collaborating with people, who are users of technology, and share knowledge and inspiration freely in a creative environment (FHAT, 2015; EJBJ, 2015; CBXT, 2015). An example of a technology of importance for NZ is washing machines, since radical changes in the integration of different technologies into a new generation of washing machines would have a large effect on the requirements for washing powder, which in turn has a large effect on enzymes (CBXT, 2015). Potentially, knowledge about systems integration obtained in open collaborative projects may be valuable to other firms in the value chain, and thus could enable NZ to present this knowledge to them: *"[…] We could go to a manufacturer of washing machines and say "we have disassembled one of your machines, to control every part of it, and now we can do things we couldn't do before, don't you think that is exciting?"* (FHAT, 2015:00:20:38). Thus, NZ could instigate (or prepare for) changes in architecture of the system in which their products, such as enzymes used for cleansing, are used. Learning to pre-empt changes in the value chain, and then accommodating NZ' offering to suit it, could help NZ avoid being disrupted or even to cause disruption. Expanding the firm's knowledge base through firm-makerspace collaborations, then, has the potential to improve the firm's ability to do future foresighting, spot trends and become more resilient, which is also reflected in the concept of 'Renewal' as an organizational benefit (Figure 10). Indeed, it can be a step towards being the first to anticipate change, implement it first and replace the old technologies faster than competitors (FHAT, 2015). This indicates the potential to provide a competitive edge as well.

6.3.5 Releasing Existing Resources

No empirical evidence was found that NZ has released existing resources as a consequence of firm-makerspace collaborations. As proposed by Danneels (2010), resource cognition can help explain how dynamic capability is exerted, as "*[...] the identification of resources and the understanding of their fungibility affect which directions of renewal are pursued."* (Danneels, 2010:3). The above sections indicate how managers perceive firm resources, their application and the potential for future application. The concept of resource cognition provides an argument for why the mode of releasing resources is not pursued or even mentioned by the interviewees as a possibility. Managers seem to not consider the action of dropping resources as a viable option to alter NZ' resource base. This is arguably a consequence of being in the very early stages of exploring this type of collaboration, where outcomes are yet to be discovered (FHAT, 2015; CBXT, 2015). However, as the firm engages in more collaborations and gains increased experience, managers' understanding of both existing resources and new resources developed through the collaborations, will arguably improve. In turn, this may lead to the discovery of resources that can be replaced and thereby released, as the resource base is altered during the process.

6.3.6 Development of a Distinct New Dynamic Capability

Eisenhardt & Martin (2000) gives the following definition of dynamic capabilities: "*The firm's processes that use resources—specifically the processes to integrate, reconfigure, gain and release resources—to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die.*" (Eisenhardt & Martin, 2000:1107). On the basis of this definition, the process of collaborations with makerspaces, which we have characterized as an ICOI process, can thus be identified as a dynamic capability in itself. The knowledge benefits of firm-makerspace collaboration were comprehensive as indicated by the analysis and the empirical data (Figure 6). Indeed, the firm-makerspace collaboration process can arguably be viewed as a 'knowledge creation process', which is

"[…] a crucial dynamic capability especially within high-technology firms. A common feature across successful knowledge creation processes is explicit linkage between the focal firm and knowledge sources outside the firm." (Eisenhardt & Martin, 2000:1109).
The evolution of dynamic capabilities is guided by certain learning mechanisms, which are repeated practice, codification of experiences into technology and formal procedures, making mistakes and the pacing of experience (Eisenhardt & Martin, 2000). As NZ is in the very early stages of practicing the process of collaborating with makerspaces, this process has arguably not yet developed into a distinct dynamic capability. In relation to the learning practices (ibid), repeated practice is still needed in the form of more projects and collaborations (LAKR, 2015). So far, there are no formal procedures in place and the prototype of the ethanol sensor is the first example of technology that has been developed in collaboration with makerspaces. As codification of experiences makes them easier to apply and accelerates the building of routines (Eisenhardt & Martin, 2000), there is arguably a need for NZ to reflect upon and codify the experiences from the collaboration with BG. Moreover, it is important not to be deterred by initial failures: "*It is the "Law of Large Numbers". There will a certain amount [of projects] that fail […] But you should not jump to conclusions too quickly*" (LAKR, 2015:00:16:57). For firms that are used to focusing on the commercial value of projects, it may be a challenge to persistently pursue firm-makerspace collaborations as failures may occur and as outcomes are uncertain and likely to be intangible. The cost of failures in firm-makerspace collaborations are relatively small compared to other R&D activities (LAKR, 2015), which can make them easier to cope with and learn from (Eisenhardt & Martin, 2000). In addition, time is required, since the pace of experiences should not be too frequent, since too many experiences in a short period of time may lead to inability to transform them into meaningful learning, or too infrequent, since this may result in forgetting what was learned thus hurting the accumulation of knowledge (ibid). This adds to the urgency of engaging in firm-makerspace collaborations, although it is not an established business practice in general. If the practice becomes a dominant form of innovation process, it could have negative consequences for firms that did not embrace the phenomenon proactively, as they may struggle to catch up with those that did.

These learnings processes are also likely to improve managers' resource cognition. Managers may discover new areas of application for the firm's resources through makerspace collaborations, and develop mental models that they would otherwise not have.

Based on the analysis of this study, firm-makerspace collaboration could be a path to develop a new dynamic capability, which can improve the firm's integrative competencies and enable the firm to better respond to changes in the environment and achieve new value-adding resource configurations.

6.3.7 Conclusion of Analysis Part 3

The analysis indicates that firm employees, whose human capital is a resource in itself, can be utilized in new ways through makerspace collaborations. The foremost way for NZ to leverage existing resources in new ways, is to have employees engage with makerspaces in order to span boundaries and leverage knowledge flows by directing them into the firm.
Additionally, through firm-makerspace collaboration, NZ can access new resources otherwise not found internally. They can tap into the human capital of makerspaces and benefit from the interdisciplinarity and freedom to fail and create, thereby learning from novel processes of combining and applying technologies, i.e. bodies of practice.

The indications of the creation of new resources were more prospective in nature. The analysis pointed to potential new resources in four main areas. Firm-makerspace collaboration could foster a new dimension in the mindsets of employees, aid in improving customer solutions, lead to new processes for R&D and develop the firm's ability to address environmental changes, including facing disruption. Thus, Proposition 3 was partially supported, as the mode of releasing resources was not found applicable.

Proposition 3: Firms can improve their dynamic capabilities through firm-makerspace collaboration by leveraging existing resources in new ways, accessing new resources externally, creating new resources and releasing resources.

The proposition above serves as the basis for answering sub-question 3: *How can firm-makerspace collaboration affect the firm's ability to alter its resource base in a dynamic capability perspective?*

Firm-makerspace collaboration can serve as a way to obtain valuable knowledge about developments in technology, processes and application of technology, in order to match capabilities with the requirements of new competitive contexts. Thus, it is a new and complementary way to achieve resource configurations, which would not have been conceived internally, through working with actors who have a completely different skillsets, and who are unconstrained by path-dependencies and idiosyncrasies of the firm.

Through engaging with makerspaces, then, the firm can benefit by absorbing a variety of input towards achieving new resource configurations that fit the evolution of the competitive context.

7. Discussion

The findings from the analysis give rise to several new issues and implications. First, the analytical findings require a revision of our theoretical framework and propositions formed initially. Second, further managerial implications selected from particularly interesting findings in the analysis are discussed. Finally, we will discuss limitations of our research and directions for future research.

7.1 Revised Framework for Firm-Makerspace Collaborations

7.1.1 The Stages of 'Defining' and 'Finding Participants'

The process model for ICOI suggests four distinct stages. The first stage, 'Defining', incorporates firm actions prior to the collaboration. The firm should formulate the problem, which it seeks to address, in a problem statement including a task description and consider the rules of cooperation. In addition the firm needs to consider the resources that it is willing to provide (Piller & West, 2014). In the second stage, 'Finding participants', firms need to identify the right participants, with relevant skills and interests, to address the problem (ibid:42-44). Once identified, the firm should try to motivate the participants to engage in collaboration with the firm. The findings of our analysis suggest that all of the above activities are done together with makerspace participants rather than by the firm alone, which has implications for the first two stages as we will discuss below.

Although firms should identify a broad area of interest that they wish to pursue prior to the collaboration, the specific problem formulation is developed together in the interactions between firm employees and makerspace participants, as found in analysis section 6.1. In this process, the project will take form based on the interaction and discussions, and participants interested in the project will join, while those who are uninterested will leave. In addition, given the great diversity of makerspaces, the firm will arguably know better what projects can be purposefully undertaken when getting to know the participants in the makerspace and their skills. Perhaps more importantly, given the interdisciplinary nature of makerspaces, inputs and ideas from makerspace participants may result in innovative projects, which the firm could not have defined on its own. We found that the processes of defining the problem and finding the right participants therefore are intertwined, and the two stages should not be separate but rather occur simultaneously. Further, this ensures that the project allows for the motivational factors of freedom, enjoyment, social interaction and challenge, for both employees and makerspace participants, as both sides are involved in the development of the project. As a consequence of the above findings, establishing a relation to the makerspace participants becomes the first part of the process in order to initiate these joint project discussions. Our findings thus lead us to merge the two stages into one stage, which we term 'Establishing a relation and jointly defining projects with participants'.

Regarding the propositions revolving around the first two stages, support was found for all propositions although there were noteworthy additional findings. Firm employees were, like the makerspace participants, motivated by enjoyment and learning opportunities. In addition, it was found that a lack of perceived management support was demotivating for firm employees to engage in makerspace collaborations. We suggest that feedback and support from management are particularly important for employees to undertake new types of innovation processes not traditionally associated with the firm's core processes and with value creation. Proposition 1.b was therefore adjusted to the following:

Proposition 1.b: Firm employees will be motivated to engage in collaboration in makerspaces by enjoyment, learning, freedom and creativity as well as the challenge of working on interesting tasks not found in their daily work environment, while management support is required to not impede these motivational factors.

While preemptive generosity was found to motivate makerspace participants to engage in collaboration, contributions of any kind should be free of any requirements of long term commitment or outcomes. Moreover, the contributions to the individual relations was found to be very strong and even more valuable than contributions to the makerspace as a whole. Proposition 1.c was therefore adjusted to the following:

Proposition 1.c: Firms can motivate makerspace participants to engage in collaboration through preemptive generosity, as long as contributions carry no obligations for makerspace participants, and should focus on establishing individual relations.

7.1.2 The Stage of 'Collaborating'

In the stage 'Collaborating', we found support for all of our propositions. For Proposition 2.b there was an additional finding, that the possibility to influence work in makerspaces is enabled through the firm employees and their participation, including taking initiatives to start projects, motivating participants to join and arguing for the direction of the project. This individual influence can thus enable influence on the project level but not on the organizational level as found in analysis section 6.2. We therefore adjust Proposition 2.b to the following:

Proposition 2.b: Firm employees can build trust and gain influence by making strong technical, communication and coordination efforts, and thus increase the possibility for the firm to influence community work towards valuable agendas on the project level.

While there are rich opportunities for all participants to engage in several projects, we argue based on the analysis, that in the collaborating stage, new participants may join or leave and ideas for new projects or the discovery of new problems may occur during the process. Moreover, if many or key project participants leave during the collaborating stage, the firm may go back to the first stage and try to engage with new participants and get them to join instead of closing down the project. The advantage of having the freedom to go back to stage one may also be significant in case severe technical obstacles are encountered during the collaborating stage, where input from new participants or other communities are needed to proceed.

We therefore propose a bidirectional influence between the first stage, 'Establishing a relation and jointly defining projects with participants' and the second stage 'Collaborating', as the two stages are likely to provide input to and affect one another.

7.1.3 The Stage of 'Leveraging'

Our analysis of the final stage, 'Leveraging', provided partial support for Proposition 3, as support was not found for the specific mode of releasing resources. This mode is thus excluded from the proposition, which is adjusted to:

Proposition 3: Firms can improve their dynamic capabilities through firm-makerspace collaboration by leveraging existing resources in new ways, accessing new resources externally and creating new resources.

In this stage, the challenge is to realize the benefits from the collaborative effort by integrating them into the firm, and the nature of the benefits greatly influences the mode of integration (Piller & West, 2014). The analysis took a dynamic capability perspective and found that benefits from makerspace collaborations could be leveraged through several modes of dynamic capability, and that the activities could improve the firm's dynamic capabilities. The nature of the benefits were primarily knowledge and intangible resources. However, since this type of collaboration is a fairly new phenomenon, repetitive projects over time are required to know more about the nature of potential benefits and thereby the modes of integration. Because of the limited number of empirical cases of actual integration of benefits from firm-makerspace collaborations, we propose an adjustment to the name of this stage, to reflect the learning process of discovering potential benefits, and how they are best leveraged. We therefore propose to term the final stage 'Discovering and leveraging benefits from collaboration'.

From the notion of learning while leveraging, a discussion of the direction of influence between stages becomes interesting. By leveraging the benefits of the collaborations, the firm and its employees will arguably develop a better understanding of particular value creating modes of collaborating, which can affect the collaborating stage. Moreover, if the firm encounters problems when trying to leverage and integrate a technology, it could go back to the collaborating stage to do more work on the project, with the help of makerspace participants, before again trying to integrate it. In addition, during the collaborating stage, different types of benefits are likely to emerge thus widening the understanding of their nature and thereby how to leverage them. We therefore propose a bidirectional influence between the stages 'Collaborating' and 'Discovering and leveraging benefits from collaboration'.

Discovering the potential benefits and how to leverage them, will arguably build the firm's capability to identify and initiate value creating projects to be undertaken in collaborations with makerspace participants. In addition, as more projects are carried out, the network of the firm employees is likely to grow, thus improving possibilities to contact and engage in collaboration with relevant participants. We argue that there may exist a self-reinforcing effect between engaging in more projects and increasing the size of the network and thereby the pool of human capital to tap into. We propose, that this in turn will improve the ability to understand and utilize the potential benefits of makerspaces and their networks. Additionally, initiating new projects and forming ties to new participants may even help the firm leverage results from other ongoing projects, as they may discover people with new competencies and ideas. We therefore also propose a bidirectional influence between the stages of 'Establishing a relation and jointly defining projects with participants' and 'Discovering and leveraging benefits from collaboration'.

7.1.4 Overview of Revised Framework

Table 4 provides an overview of our revised framework and Figure 11 illustrates our suggested process model for firm-makerspace collaborations.

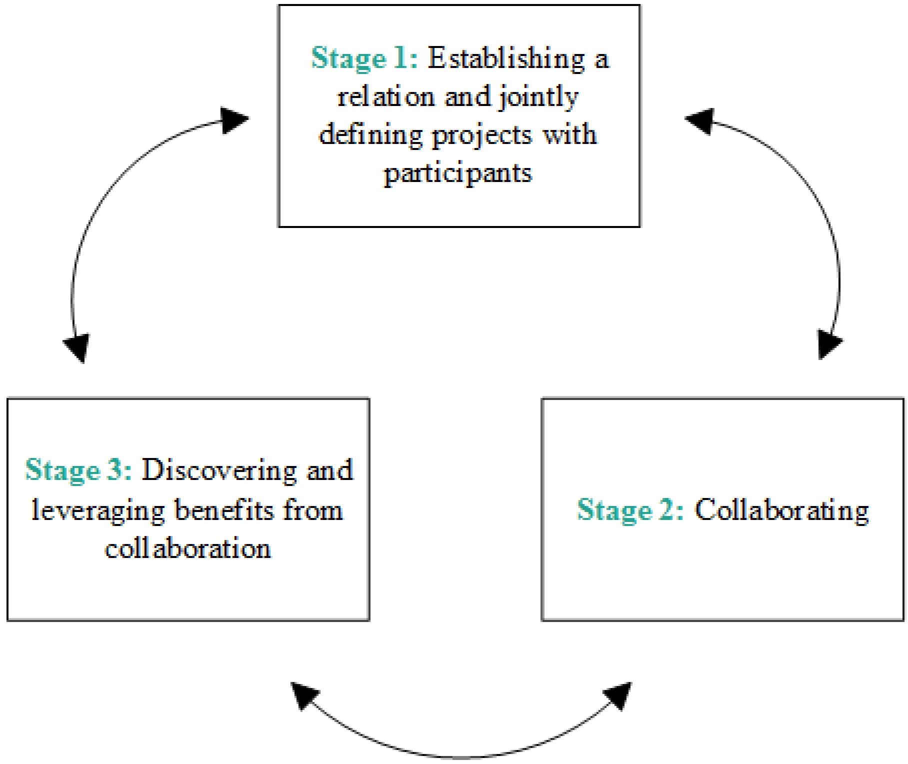

Figure 11 - Process model for firm-makerspace collaboration. Source: own model

The model illustrates the cycle of learning and capability building, that arguably will occur as more and more projects are carried out over time – in other words, it also illustrates the development of a distinct dynamic capability mentioned in section 6.3.6. Moreover, it reflects the volatile and dynamic nature of makerspaces incorporated in firm-makerspace collaborations, where shifting back and forth between stages is possible and likely, since projects do not follow stage-gate like models. This can arguably provide advantages in the form of a more agile approach to innovation.

Table 4 - Revised theoretical framework

Stage	Sub-question	Propositions
1. Establishing a relation and jointly defining projects with participants	Sub-question 1: How can firm employees and makerspace participants be motivated to engage in firm-makerspace collaboration?	Proposition 1.a: Makerspace participants will primarily be motivated to engage in collaboration by intrinsic motivational factors, such as enjoyment, learning, challenge, freedom and social interaction. Proposition 1.b: Firm employees will be motivated to engage in collaboration in makerspaces by enjoyment, learning, freedom and creativity as well as the challenge of working on new tasks not found in their daily work environment, while management support is required to not impede these motivational factors. Proposition 1.c: Firms can motivate makerspace participants to engage in collaboration through preemptive generosity, as long as contributions carry no obligations for makerspace participants, and should focus on establishing individual relations.
2. Collaborating	Sub-question 2: How should firm-makerspace collaboration be organized and governed?	Proposition 2.a: Firms should maintain an interactive relation, by dedicating resources, in the form of employees, to actively participate in makerspaces in order to increase motivation and engagement from makerspace participants. Proposition 2.b: Firm employees can build trust and gain influence by making strong technical, communication and coordination efforts, and thus increase the possibility for the firm to influence community work towards valuable agendas on the project level. Proposition 2.c Firm-makerspace collaboration should be characterized by adaptive governance that supports Independence, Decentralized decision-making and Autonomous participation.
3. Discovering and leveraging benefits from collaboration	Sub-question 3: How can firm-makerspace collaboration affect the firm's ability to alter its resource base in a dynamic capability perspective?	Proposition 3: Firms can improve their dynamic capabilities through firm-makerspace collaboration by leveraging existing resources in new ways, accessing new resources externally and creating new resources.

7.2 Further Managerial Implications

7.2.1 Contrasting Logics

In the analysis, we found that there is potential for valuable outcomes through firm-makerspace collaboration, despite a lack of contracts and the inability to enact any form of IP protection. However, it was also clear that there was reluctance from employees, who doubted the commercial value of such an endeavor. Furthermore, it is challenging for firms to cede control of the process – something quite alien to a large R&D intensive firm with a patent-based business model and a system of performance measures.

Furthermore, our revised framework for firm-makerspace collaboration presents a different way of working with OI, and thus poses additional challenges to understand and react to for a firm, particularly in light of the finding that relations are managed and built at individual level in makerspaces. These managerial implications of the clash between the open world of makerspaces and the more closed organization of a R&D intensive firm will be elaborated in the following.

7.2.1.1. Overcoming Internal Reluctance

There were unexpected findings in the analysis sections 6.1.2 and 6.2.3, namely that lack of management support was demotivating and abolishing contracts made NZ employees perceive effort spent in makerspace collaboration to be of uncertain value. Although NZ employees would be motivated to participate, as collaboration would be enjoyable and interesting (Figure 8), the 'Barriers & challenges to collaboration' (Figure 2) would lead them to prioritize their effort elsewhere: *"But I'm not sure I could get my managers convinced that I should spend an entire day a week doing it. Even though I would find it fun. If I had the time, I would like to go."* (MTFR, 2015:00:27:34).

For managers who wish to motivate employees, Vroom's 'Expectancy Theory' (Larsson, 2010:43) provides an approachable model. The component of 'expectancy', namely a perception that effort will lead to a desirable performance goal, hinges on demonstrating that the possible, non-patentable outcomes of firm-makerspace collaboration are achievable and valuable, despite the difficulties in measuring these: *"There has to be people who believe in this in Novozymes, and that is easier to achieve, if we can prove value in these contexts [...] So we get some indicators of the advantages from engaging in some way in these open networks."* (EJBJ, 2015:00:39:10). This is easier said than done – presenting a slide deck touting the intangible effects of such collaborations will likely be ineffective

(GEAB, 2015). Rather, there needs to be a continuous stream of tangible success stories (CBXT, 2015), showing that this way of working can produce valuable outcomes. Here, physical artefacts of collaboration such as the Baessy ethanol sensor can become manifestations of the valuable outcomes, despite the product in itself not necessarily being the most important result of collaboration (GEAB, 2015).

'Instrumentality', the belief that achieving a level of performance will lead to an intrinsic or extrinsic reward, and 'valence', namely the value put on the reward by the recipient, determine how employees should be rewarded (Larsson, 2010:44). Outcomes catering to the intrinsic motivational factors found in section 6.1.2 are difficult to control for the firm, beyond selecting those who are intrinsically motivated to work in these contexts. Instead, managers could demonstrate that firm-makerspace participation is valuable to the firm and provide employees with a sense of achievement towards overarching goals (HANS, 2015; EJBJ, 2015). To this end, the decision to invest in open collaboration must be made centrally, and implemented strategically, to be motivating (HANS, 2015; LAKR, 2015). If it *"seeps down"* (CBXT, 2015:00:03:06) from top management level it can generate interest and positive feedback among employees (HANS, 2015), rather than become a fragmented effort emphasized by some and discarded by others.

Additionally, the surprising finding regarding perceptions of managerial support, could, if investigated further, provide new avenues for motivating employees. NZ employees are unsure whether their managers value, support and reward efforts for which there are no concrete business cases, product outcomes or project plans (MTFR, 2015; HANS, 2015). Thus, there must be an effort from managers to show appreciation for and reward performance, as the NZ employees perceive this as valuable but are unsure whether it is achievable through firm-makerspace collaboration. Pecuniary incentives are a common method of rewarding employees, but may be difficult to implement when the key benefits of an endeavor are intangible, and conceptualizations of what constitutes successful collaborative outcomes has yet to be established. Furthermore, NZ employees did not explicitly list pecuniary incentives as motivating. However, it is uncertain whether this is because expressing a desire for pecuniary rewards may be taboo; an effect that could be accentuated when discussing a topic such as open collaboration. Instead, it may have been incorporated in general constructions such as desire for

'Management support'. Thus, management support could be an interesting concept to elaborate further, in terms of both meaning and effect.

7.2.1.2. Embracing the Lack of Control

Having no legal measures to fall back upon, in order to maintain control of processes and tying actors to commitments, is a challenging concept to firms whose business partnerships are dominated by legal contracts (MTFR, 2015). The lack of legal commitments can lead to projects 'forking' (splitting into separate projects) or efforts being discontinued altogether, if firms and makerspace participants cannot agree on a desirable direction to take it (Harhoff & Mayrhofer, 2010:138, 143). In more extreme cases of disagreements between makerspace participants and firms, legal action may be taken (JAWE, 2015) or firms may suffer reputational damage, if disgruntled makerspace participants take their issues out in public (AABH, 2015): *"So it is Ejner [the responsible VP] who takes this risk – not only of allocating time [employee resources], but also any [negative] aftermath. When Novozymes go out in the open, anything can happen."* (AABH, 2015:00:32:29).

Lateral authority, which was analyzed in section 6.2.2, can arguably mitigate the risk of forking, when legal control is unavailable. Lateral authority, however, may be challenging to exert. Mobilizing support is a difficult skill in itself; as participants self-select for projects and are free to leave at any point, collaborations are susceptible to makerspace participants losing interest. Thus, while firm employees cannot force makerspace participants to participate, they can utilize and build motivational skills, broadcast ideas and inspire project dispositions to the community. Furthermore, assuming leadership of the process can lead to lack of trust if community members perceive the leader as controlling (Fleming & Waguespack, 2007). This goes especially for employees participating on behalf of a firm, due to inherent suspicion of commercial interests. However, social interaction can mitigate this distrust (ibid), providing further support to the argument, that continuous commitment from the firm is crucial to successful open collaboration.

Another way to mitigate the risk of forking, including makerspace participants in the project definition from the outset, as suggested by our process model for firm-makerspace collaboration (Figure 11). Involving makerspace participants in the definition of projects, increases the likelihood that they will stay engaged in the project as it caters to the motivational factors of enjoyment, interest and freedom, discussed in section 6.1.1. Furthermore, it may develop a greater sense of ownership (AABH, 2015) and attachment towards the project.

While firms can attempt to influence and enable beneficial contexts, through the participation of the employees, it is ultimately dependent on the actions of independent actors. As such, relationships must be constantly attended to and understood by firms not as another strategic alliance or other business relationship, but as a network of individual relations (Harhoff & Mayrhofer, 2010).

7.2.1.3. Understanding the Ecosystem

As firm-makerspace collaboration entails processes radically different from those of NZ, it presents a serious challenge for management. Learning to work with makerspaces, then, is neither a simple process, nor one that can be swiftly perfected. Furthermore, there are differing views on the urgency of entering such relations internally in NZ (CBXT, 2015), which can slow the process of exploring the collaboration mode further. The viability of such collaboration cannot be determined on the basis of a single project alone. While the Baessy collaboration was successful to some degree, more experiences are needed in order to grasp possible outcomes. The benefits of firm-makerspace collaboration found in the analysis are likely long-term and dependent on a certain degree of commitment from the firm. Furthermore, we argued that the process of collaborating with makerspaces is a self-reinforcing cycle, as continuous participation leads to better understanding and better network access, which in turn increases the ability of firm employees to discover and leverage benefits.

Participation should be increased through involving more people with the right mindset and having them fully immerse themselves in the communities, without the traditional requirements for status reports and short-term goals (LAKR, 2015). At NZ, employees are trusted to be able to prioritize their own efforts autonomously (FIOD, 2015), which is a crucial asset for a firm looking to send employees out in unfamiliar contexts. While employee work hours would need to be invested in the project, it is otherwise a relatively cheap bet compared to how much firms spend on R&D (LAKR, 2015), requiring no contracts or use of internal equipment or lab space. As of now, NZ are working cautiously and choosing to collaborate on non-core areas, in which failure or spillovers pose no threat to the firm's core businesses (CBXT, 2015). Thus, the worst-case scenario is that the individual project fails, but a new one can often be spawned from the collaboration and the learning achieved from engaging with the community.

Finally, it is important to note that we do not propose in any way that firm-makerspace collaboration should supplant the core processes that have made NZ great and is generating revenues through contractual partnerships and internal innovation efforts. Firm-makerspace collaboration can run parallel to the core processes. It is not a collaboration form that will necessarily provide the new core product or service. Rather it can provide new inputs and insights into how NZ can continue to be successful, and how to adapt to changes in the competitive context. It is a way to remain in touch with current and future developments in the pool of distributed knowledge – an asset which will only grow increasingly relevant over time: *"It is not as if we know today, how we will be successful, but we know that it is necessary and we will continue working with it."* (EJBJ, 2015:00:26:00).

7.2.2 Alternative Modes of Organizing the Collaboration

This research focused on how firms can engage with existing makerspaces and their networks in open firm-makerspace collaborations outside of the firm. The premises for this type of collaboration was to send employees out to work in these makerspaces, cede direct control of the process and its outcomes and adapt to makerspace logics. However, there are alternative ways to collaborate with the people participating in such innovation communities (Harhoff & Mayrhofer, 2010).

One such alternative is firm-hosted communities, which have been studied primarily in the context of online communities, more specifically OSS communities (West & O'Mahony, 2008; O'Mahony, 2007; Shah, 2006; Teigland, et al., 2014; Jarvenpaa & Lang, 2011). Hosting or sponsoring one's own community gives the firm possibilities to retain some degree of control and to direct community work towards business goals through 'boundary management' (Teigland, et al., 2014:27; Jarvenpaa & Lang, 2011). This can potentially enable a more structured and controlled environment than found in autonomous makerspaces. However, this gives rise to several issues of importance. First, firm control and ownership may be disapproved of by participants and thereby hurt motivation to collaborate (Shah, 2006). The motivational factors found in section 6.1.1 are indeed susceptible to violation by firm control and ownership. More specifically, 'Freedom' and 'Interest' (Figure 8) could be hurt, as several of the makerspace participants stated when asked about firm-hosted communities: *"[…] If I didn't get to decide what to work on myself, why should I go there? It totally depends on what the premises are. Am I allowed to borrow their equipment and can I borrow it to do some of my own tests?"* (MMBO, 2015:00:28:24) and *"I'm not sure if many would be interested in going out to Novozymes, because it* *would connote the firm's ownership and their premises, and a big part of getting volunteers to make something, is to give them ownership and freedom to do it in the way they wish"* (EMPO, 2015:00:46:04). Moreover, the inherent openness of makerspaces and their participants (Figure 7), as well as the importance of keeping knowledge open in firm-makerspace collaborations (MIAL, 2015), may be violated if the firm tries to protect the knowledge created. Our findings in section 6.2.3 indicated the importance of adaptive governance in firm-makerspace collaboration, which may also be violated if firms are trying to exert more control. This could arguably affect the stability of relations between firm and community, which are only expected to be sustainable if the norms of the community are not violated (Harhoff & Mayrhofer, 2010). Balancing this tension within the inherent trade-offs between openness and control is one of the objectives of 'boundary management' (Teigland, et al., 2014:27) and thus presents a serious challenge for firms looking to establish their own makerspace communities. Second, it may prove very challenging to attract enough people and the right people to the community. Indeed, competition for contributors is apparent as they can freely join and leave different communities, and the competitive forces are likely to be fostered as more communities emerge, and more firms try to establish their own (Harhoff & Mayrhofer, 2010). In addition, by establishing one's own community, the firm does not get access to the same network as if they went out to participate in existing communities (LAKR, 2015). Instead, the firm has to invest much more time and resources to establish the community and build a network (LAKR, 2015). Thus, there is a risk that the firm-hosted community will be populated largely by the firm's employees due to the challenge of attracting a critical mass of external contributors (LAKR, 2015). This may cause the firm to miss out on many of the network benefits that emerged from our findings, such as 'Extending reach' and 'Many contributors' (Figure 9). Third, several studies have compared firm-hosted communities and autonomous communities and found that autonomous communities are more innovative and productive (Teigland, et al., 2014; Jarvenpaa & Lang, 2011; West & O'Mahony, 2008). In firm-hosted communities, a large amount of work may shift towards firm employees (Teigland, et al., 2014) and the content created becomes more homogeneous (Jarvenpaa & Lang, 2011). Depending on the strategy of the firm and the intended role of the community, this may be problematic as our findings indicate that significant strengths of makerspaces rest within the heterogeneity of participants and their interdisciplinarity (Figure 6 & 7). Autonomous communities were found to produce more heterogeneous and innovative content (Jarvenpaa & Lang, 2011) and could attract more participants because of a higher degree of openness and accessibility (West & O'Mahony, 2008). However, while being less constrained by special interests, behavior and performance is also less predictable and more difficult to manage in this type of community (Jarvenpaa & Lang, 2011), which is also reflected in the findings from our analysis.

As a less extensive alternative, firms can host activities for voluntary participants instead of hosting a makerspace. In our empirical data, several makerspace participants expressed interest in events hosted by firms. Specifically, hosting talks or workshops were mentioned as having great potential for attracting makerspace participants (SSØR, 2015; EMPO, 2015; MIAL, 2015; MMBO, 2015).

Finally, while this research found that collaborations with makerspaces should be open and the firm should adapt to makerspace logics and cede control, there may be various viable collaboration terms. Given the diversity of makerspaces, there may be groups of participants with more commercially oriented interests, the same kind of people that would engage in start-ups, who would be interested in a more closed form of collaboration with firms.

Based on our analysis, empirical findings and studies on firm-hosted communities, we argue that inactive-participation, simply watching and monitoring makerspaces, provides only superficial insights, while firm-hosted communities, with more structure and control, may demotivate some types of makerspace participants and constrain the potential benefits. A third mode then, dedicating employees to engage in makerspace projects, as proposed in our framework, seems as a sensible way to start practicing and exploring firm-makerspace collaborations. In time, as more experience is gained, the firm may then be better equipped to establish their own makerspace community, establish internal makerspace-like innovation processes or other initiatives. However, depending on the strategy and the resources of the firm, alternative modes may also be suitable for a firm to pursue from the outset.

7.2.3 Hybrid Organizing

Any form of collaboration with makerspaces arguably requires internal adoption of new practices and belief systems, also termed 'institutional logics' (Battilana & Lee, 2014:402). The combination of different institutional logics within the same organization is reflected in the concept of 'Hybridity' (ibid: 402). An R&D intensive firm seeking to combine its traditionally closed culture, focus on IPR and structured processes, with the open and unstructured innovation processes of makerspace communities, thus faces the task of 'Hybrid organizing', which has been defined as: "*the activities, structures, processes and meanings by which organizations make sense of and combine multiple organizational forms.*" (ibid: 397). We argue that the challenges and issues arising from hybrid organizing become especially important for management to attend to in the future, if they seek to integrate makerspace practices internally one way or another. The combination of aspects of academic research organizations and business organizations in Biotechnology firms has been described as hybrid organizing (ibid:401). For NZ, as a biotechnology firm, it could pose a tremendous challenge to integrate a third logic, the open community logic of makerspaces. However, the combination of different organizational forms has, under certain conditions, been proposed to enable greater opportunities for change and flexibility in adapting to changing environments (ibid:424). This is in line with our findings in section 6.3, that firm-makerspace collaboration can help improve the firm's dynamic capability. Battilana & Lee (2014) suggest that the realization of outcomes is dependent on five organizational factors that affect how organizations experience the conflicts and synergies that arise through combination of different logics and forms (ibid:424). These organizational factors may be more or less differentiated or integrated.

The first factor, 'organizational activities', revolves around the integration of activities that the hybrid organization engages in; whether goals are pursued through separate sets or a common set of activities (ibid:413). As indicated in our analysis, the activities of NZ are inherently different from the activities of makerspaces and are working to serve different goals. This could likely lead to separate sets of activities, which can lead to tensions around allocation of human, financial and attentional resources, as well as challenges to gain legitimacy from multiple external stakeholders (ibid:413-415). As already discussed, management faces a challenge of proving the value of makerspace activities, which could lead to tension around resource allocations. Furthermore, one could imagine that many shareholders would value traditional commercially oriented processes over the more elusive processes of makerspace collaboration, which does not always include a clear value-creating commercial goal at the end.

The second factor, 'workforce composition', revolves around the importance of alignment between employee identities and the combination of organizational forms (ibid:415-416). The experiences and training of individuals socializes them into developing dispositions for specific organizational forms.

Multiple identities of the organization may either be shared by its members or carried by distinct subgroups within the organization. Alignment of individual and organizational identities are likely to improve organizational commitment and reduce the risk of intra-organizational conflicts (ibid:416). Because of the inherently different nature of traditional work processes in NZ and the work processes at makerspaces, it may indeed take time for employees to become 'hybrid individuals' (ibid:415), who are socialized into the multiple organizational forms. It may be more likely that subgroups will be created, where the employees taking part in firm-makerspace collaborations are more likely to become hybrid individuals, while the employees not participating would be likely to stick to their traditional identity. Since the latter group would be the largest by far, the majority of employees may lack commitment to the activities stemming from the makerspace logics. Moreover, employees may have to unlearn some of their working habits to become hybrid individuals (ibid:417), which could prove challenging to the individuals taking part in makerspace activities. Thus, management face a serious challenge of aligning individual and organizational identities and developing hybrid individuals.

The third factor, 'organization design', revolves around 'organization structure', that affects where tensions in the organization will emerge, the 'incentives and control systems', which affect the behaviors of organization members, and 'governance', which affects the ability to resist pressures to drift towards certain objectives at the expense of others (ibid:417-419). When hybrid activities are not well integrated and are separate, structural separation may be needed to avoid conflicts. However, this gives rise to strong requirements of coordination between the structurally separated units. Our interviews with NZ employees strongly underlined the importance of not separating makerspace activities from existing business units, as this would likely create "silos" and thereby hurt integration and potential benefits to the organization (HANS, 2015; MKBS, 2015). Thus, the structural question presents a dilemma between separating the activities to prevent conflicts and uniting them to avoid creating isolated organizational "silos". Regarding incentive systems, they can be used to teach and reinforce desired behaviors and values in organizational members (Battilana & Lee, 2014). As we found the outcomes of makerspace collaborations still to be fairly uncertain, creating incentive systems to promote these activities may be a complex task. In relation to governance systems, along with formal structure and incentive systems, they play a key role of ensuring joint accountability for objectives and to avoid a drift towards certain objectives (Battilana & Lee, 2014:419). In a large R&D intensive firm as NZ, where internal processes and IPR are critical elements of the business model, one would expect a strong pressure towards the commercial objectives of exploitation through the core business processes. Makerspace activities, which are very different and outside of the core-area of the firm (CBXT, 2015), may then find it difficult to assert their right to existence, which in turn heightens the requirements to the organizational design.

The fourth factor, 'Inter-Organizational Relationships', revolves around the consideration of the organizations' relationships with the various constituents in their environment (Battilana & Lee, 2014:420-421). In the case of NZ, we have already discussed the risk of leakage of firm insights when engaging openly with external communities, which may also become a concern for some of the customers normally collaborating with NZ in closed arrangements. On the other hand, by engaging in open collaborations, NZ as an organization may become more attractive to other open communities across the world or to some investors and shareholders. Indeed, consistent engagement may build trust and authenticity, which we found to be very important due to the initial suspicious attitude towards firm intentions.

The fifth factor, 'culture', revolves around the possibility of a coherent culture integrating different organizational forms compared to the creation of multiple subcultures, where a coherent culture may not be desirable, if it requires the reconciliation of competing norms and values (ibid:421). Again, this resembles the inevitable challenge of uniting the contrasting logics of firm-makerspace collaborations and the traditional core processes of the firm. The competing norms and values of closed versus open collaboration, IPR versus open knowledge-sharing and structured versus loose and dynamic innovation processes may not be possible to reconcile in a coherent culture. Leadership can play an important role in the development of organizational culture, and in hybrid organizations leaders face a particular complex task to create a "whole" entity and of *"[…] constructing systems of meaning where multiple conceptions of the organization's values are possible or even likely*" (ibid:422). To make it even more complex, perceptions of value may differ between departments internally in NZ. Basic research units may be more open to makerspace activities than applied research units, which are closer to customers and thus have a more commercially focused mindset.

Hybridity requires that the combination of different organizational logics are *"[…] central and persistent within a given entity, rather than adaptive and transitory"* (ibid:400). NZ has just begun to explore makerspaces and their networks and has not substantially integrated the new logics, and therefore cannot yet be characterized as a hybrid firm that combines their current logics with the makerspace logics. We argue, however, that the concept and challenges of hybrid organizing discussed above may indeed become very important in the future as NZ build experience and may become more and more involved, while the world continues to change at a rapid rate. Thus, hybrid organizing may become a central concept for future research.

7.3 Limitations and Future Research

This paper contributes to the, to our knowledge, underexplored area of open collaboration between makerspaces and firms by proposing an initial framework for firm-makerspace collaboration. Although we have arrived at theoretically and empirically founded propositions, there are several limitations to the study.

First and foremost of these is the relative dearth of literature concerning the particular empirical phenomenon. Although the literature on OI and UI is thoroughly covered, the empirical basis for such analyses focus primarily on interfirm collaborations and firm-sponsored communities. As a result, most of the theories are utilized under the assumption of, and to test, their applicability to firm-makerspace collaborations. While this application, largely held true for this particular study, further research must be done in other contexts to verify a more general applicability of the findings.

7.3.1 Makerspace Heterogeneity

The term makerspace covers a wide array of organizational setups and membership compositions. Thus, the one makerspace focused on in this study does not necessarily represent the wider spectrum of makerspace configurations, nor the vast number of different collaborations that can potentially be set up between any number of firms and makerspaces.

While makerspaces in Denmark were easy to access, they are few, young, and with relatively small membership bases compared to those abroad. U.S. based makerspaces, characterized by professionalism and access to powerful equipment (NNIS, 2015) or Indian makerspaces, characterized by a vast number of members (AABH, 2015), could provide completely different perspectives and possibly increased potential for innovation.

Even the internal heterogeneity of participants in the makerspace is difficult to encompass in our study, in which five members where interviewed. Had other makerspace participants volunteered for interviews, different views would likely have surfaced, as not only a wide spectrum of disciplines are represented in the makerspace, but an equally diverse set of attitudes are present, especially regarding collaborations with firms (EMPO, 2015). It is entirely possible that the makerspace participants who agreed to be interviewed possess certain characteristics, whereas those who were not interviewed may possess others, and thus an incomplete picture of the makerspace participants is drawn. However, those interviewed were some of the more heavily involved members in the community and thus had extensive knowledge of the people whom they represented, and were focused on delivering a rich view of the heterogeneity inside the makerspace – an attribute that was important for them to convey.

Finally, firms can differ vastly in the way they approach and engage with makerspaces, but also in the outcome of collaboration and how the firms attempt to leverage said outcome.

Thus, further research covering the different collaborations that will likely emerge in the future could shed light on the intricacies of working with different makerspaces in varying contexts. Particularly interesting would be an analysis of the productivity and output of individual makerspaces, and whether this could be tied to the attributes of said makerspaces, such as location, composition or structure.

7.3.2 Exploring a New Phenomenon

This explorative study covers an area yet largely undefined in both theory and practice. Thus, the theoretical framework, in which we have operated, was initially broad in scope and many different avenues for research could have been chosen. With Piller & West's (2014) framework as our initial point of departure the focus of the analysis has naturally gravitated towards the key activities mentioned there. The list of activities is not necessarily exhaustive, and many more could presumably be found by researchers choosing a different vantage point, from which to view the concept of firm-makerspace collaboration.

Particularly stage 3 of our revised framework is in much need of elaboration. Firm-makerspace collaboration is yet in its infancy, and several statements regarding benefits of engaging in this form of collaboration are hypothetical, based on theoretical insights or indications of developing trends as perceived by our interviewees. Particularly, the process of integrating the results of firm-makerspace collaboration into the firm is a lengthy process, which has arguably not been realized yet. Indeed, the creation of new company-wide competencies as a result of firm-makerspace collaborations is an area of interest for future research. Elaborating on this would require a longitudinal and internal study of NZ, in order to discover fully the dynamics of integrating a new work process.

In the analysis of stage 3, the possible beneficial outcomes of collaboration revolved around the concept of dynamic capabilities and how the firm could evolve these through collaboration. However, other perspectives could have been taken to arrive at different benefits, many of which were hinted at in the empirical data. The diffusion of knowledge agendas could be one area to explore, or even how NZ could increase awareness of the possibilities for solving societal problems through the use of enzymes. To this end, a stakeholder perspective could uncover benefits of engaging society on a wider basis, and provide a starting point for analyzing the branding and reputational benefits of participating in the generation of public knowledge through firm-makerspace collaborations.
Alternatively, a human resource perspective could have been taken, exploring further the benefits of improving the knowledge of employees, while also delving into the other possible benefits of firm-makerspace collaboration, such as increased motivation and potential for hiring makerspace participants into the firm.

Finally, further research on the possibilities for firm employees to gain lateral authority and community leadership in makerspaces are needed. We found indications of rich possibilities to pursue such informal leadership positions, but concrete evidence of such efforts were not available, possibly as a consequence of our data collection method. In-depth research methods, such as 'ethnographic research' (Bryman & Bell, 2011:426), could potentially shed light on the social dynamics of firm-makerspace collaborations. Similarly, our findings indicate the potential for spanning community boundaries and build social capital through firm-makerspace collaboration, but thorough network analyses are needed to investigate this issue further.

7.3.3 Alternative Modes of Collaboration and Hybrid Organizing

As already discussed, there are alternative modes of organizing the collaboration with makerspace participants or open communities in general. Future research is needed to shed light on the effects and benefits of the continuum of firm-makerspace collaboration modes. In addition, the concept of hybrid organizing, and how to handle the inherent challenges brought along, become an interesting path for future research. The five organizational modes affecting hybrid organizing can be more or less integrated and can therefore result in many distinct configurations of hybrid organizations. The organizational outcomes of these distinct configurations are an interesting research area. Extensive research on a large amount of empirical cases is further required to elaborate on the implications for management in large R&D intensive firms.

8. Conclusion

The overall research question of our thesis was:

How can a large R&D-intensive firm engage in open collaboration with makerspace communities, and how can it affect the firm's ability to alter its resource base in a dynamic capability perspective?

We divided this into three sub-questions to guide the research, concerning 1) Individual motivation to engage in collaboration, 2) Organization and governance of the collaboration and 3) The effect on the firm's ability to achieve new resource configurations.

As a result of limited prior research on firm-makerspace collaborations, we looked to adjacent areas of research conducted on OSS communities and firm-hosted communities as well as established literature on OI, UI and dynamic capabilities. We assembled insights from the literature into an initial theoretical framework, and from there we delved into the different stages of the collaboration process in an empirical analysis. Focus of the empirical analysis was a case of open collaboration between NZ and BG, which shed light on the processes of firm-makerspace collaboration. The inferences from the initial framework were primarily supported, although we discovered several deviations and therefore revised the framework and arrived at our own process model for firm-makerspace collaboration. We present the key findings from the analysis of each sub-question below, before presenting our final concluding remarks.

Sub-question 1: How can firm employees and makerspace participants be motivated to engage in firm-makerspace collaboration?

We found that individual motivation for both makerspace participants and firm employees, to engage in firm-makerspace collaboration, was primarily intrinsic in nature reflected in motivational factors of enjoyment, learning, interest and freedom. In addition, social motivation was important to makerspace participants, while the possibility to work outside their normal environment was motivating for employees. Moreover, lack of management support was found to be a deterrent to motivation for firm employees.

When engaging in collaboration, it was important for makerspace participants to participate in the development and definition of the projects, as this served to ensure alignment with the motivational factors. Preemptive generosity, primarily through contributions of any kind made by individuals, was found to be important in order to establish a trusting relation that encouraged reciprocated efforts. These insights led us to merge the two first stages of our initial framework into one stage, as we found the activities of establishing a relation, defining projects and finding and motivating participants to be intertwined. This first stage of the collaboration process, we therefore termed 'Establishing a relation and jointly defining projects with participants'.

Sub-question 2: How should firm-makerspace collaboration be organized and governed?

In the second stage, 'Collaborating', we found several implications for the organization and governance of the collaboration process. Following the actions of stage 1, firms should dedicate employees to actively participate in projects continuously. Indeed, continuous commitment was a key element to sustain motivation, build trust and help initiate and coordinate project work. The active efforts put into coordination and communication were moreover found to enable the possibility for firm employees to attain lateral authority. In turn, lateral authority was found to enable firm employees to gain influence at the project level, but not at the organizational level.
Formal control and contracts, however, were ceded by the firm, in order not to violate the values and inherent characteristics of the makerspace environment. The approach of adaptive governance was taken in order to ensure participants' independence, decentralized decision-making and allow for autonomous participation. The consequences of this approach, were issues of lack of control and uncertainty among firm employees about the value of firm-makerspace collaborations.

Overall, the project should be organized and governed in an open manner and through interactions between individuals in order to adapt to the logics of the community and to sustain motivation among participants.

Sub-question 3: How can firm-makerspace collaboration affect the firm's ability to alter its resource base in a dynamic capability perspective?

In the third stage of the firm-makerspace collaboration, the firm seeks to realize benefits from the collaboration. We found that several benefits could be realized by establishing new resource configurations through three modes of dynamic capability, namely leveraging existing resources in new ways, accessing external resources and creating new resources internally.

Firm employees, human capital resources, can be leveraged by sending them out to participate in open collaboration projects at makerspaces. Through their participation they build a bridge between the firm and the makerspace through obtaining, filtering and directing important knowledge back to the firm. Furthermore, they enable access to external resources, such as the large and diverse pool of human capital in makerspaces and their networks, as well as new bodies of practice developed through innovation processes in these environments characterized by a high degree of freedom. Internally new resources can be created as knowledge and experience is obtained through the makerspace collaborations, including a new cultural dimension, improved customer solutions, new R&D processes and improved resilience in the face of environmental changes.
We found that firm-makerspace collaboration can help improve the firm's dynamic capability, as the firm becomes more capable of altering its resource base, in new ways otherwise not achievable. We also found that a large part of leveraging benefits, was a learning process of discovering potential benefits and how to integrate them. We therefore termed the third stage 'Discovering and leveraging benefits from collaboration'.

The key findings from our analysis of each sub-question together answer our overall research question. Our findings lead us to believe that firms seeking to engage in open collaborations with makerspaces should do so through the three stages and related activities accounted for above. In our revised framework we emphasize the bidirectional influence between the three stages and the advantage of the dynamic nature of the collaboration, whereby it is possible to go back to earlier stages along the process if needed, e.g. to develop or adjust the project further or to find new participants.

We finally discussed inherent challenges in combining the very different logics of the firm and the makerspaces. The most prevalent challenges found were to overcome internal reluctance, embrace the lack of control and to understand the makerspace ecosystem.

The contribution of this research is thus to provide explorative theoretical and empirical insights on the field of open collaboration between firms and physical DIY communities, more specifically makerspaces, and propose a process model for firm-makerspace collaboration. Future research within this field is required to test and elaborate on our framework as a larger amount of empirical cases emerge over time. The novelty of the phenomenon means that many aspects, both benefits and challenges, are still to be discovered, and our framework could serve as a starting point for further exploration of the field.

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10. Appendices

Appendix 1. Elaboration of Select Concepts

Table I. Elaboration of select concepts in: 'Barriers & challenges to collaboration'.

Concept	Explanation
Commercial value not clear	Interviewee is unsure how collaboration is valuable to the firm – particularly in terms of increased sales.
IPR & contract issues	Interviewee perceives negotiation over IP and contracts as a stumbling block to collaboration
Lack of management approval	Interviewee perceives that a lack of management approval makes employees hesitant about joining open collaboration.
Limited proof of concept	Interviewee perceives a lack of evidence of prior successful collaboration.
Makers' suspicious attitude towards firm intentions	Interviewee perceives makers as wary of being taken advantage of by firms.
Prioritization of scarce resources	Interviewee has limited resources that need to be prioritized – time spent in makerspace is time taken from other activities.

Table II. Elaboration of select concepts in: 'Defining projects'.

Concept	Explanation
Brainstorming & joint discussion	Interviewee believes various participants provide (or should provide) input in loosely organized process of defining purpose.
Common interests	Interviewee believes projects are (or should be) focused on areas of interest for both makers and employees
Goals & topics initially loosely defined	Interviewee believes projects are (or should be) undefined at first but purpose emerges during the process.
Should not involve core areas of the firm	Interviewee believes projects are (or should be) focused on areas outside the firm's core offering

Table III. Elaboration of select concepts in: 'Firm-makerspace relation'.

Concept	Explanation
Donation with no strings attached	Interviewee believes firms may donate resources to the makerspace, but that there can be no expectation of the makers providing anything in return.
Engaging through active participation	Interviewee perceives active participation in makerspaces to be important.
Establishing relations	Interviewee perceives initial relation building as an important process.

Firms should contribute to communities	Interviewee finds it important for firms to contribute something useful in order to maintain relation.
Focus on the process	Interviewee perceives the process of collaboration rather than the outcome (in terms of a product output) to be most important in firm-makerspace collaboration.
Individual relations	Interviewee perceives firm-makerspace relations to be between makers and employees individually, rather than between the firm and the makerspace as organizations.
Knowledge sharing	Interviewee perceives firm-makerspace relations to be a setting in which knowledge can be shared between the different participants.
Learning by doing	Interviewee perceives practical, hands-on learning experiences in firm-makerspace relations as the main process of learning.
Mutual benefits	Interviewee believes firm-makerspace relations can and must be beneficial to all involved parties.
Trust and authenticity	Interviewee points to the importance of individuals trusting each other and building trust through authentic behavior.

Table IV. Elaboration of select concepts in: 'Governance of collaboration'.

Concept	Explanation
Avoiding IPR issues	Interviewee believed it was important to avoid issues of IPR and ownership by making all information freely available.
Do-ocracy	Interviewee perceives that decisions in makerspaces are made by those who take action.
Firm cedes control	Interviewee finds it important that the firm tries to control neither the collaboration process nor the makers' level of commitment and participation.
Keep project open	Interviewee perceives the importance of keeping projects and knowledge open and accessible during collaboration.
Limited openness in practice	Interviewee believes that collaborations are not entirely open and transparent, as it is impossible to share all information with the whole community and there is a limit to the number of people who can actively participate in the process.

Table V. Elaboration of select concepts in: 'Knowledge benefits'.

Concept	Explanation
Absorbing new inputs	Interviewee believes makerspace collaboration can help transfer new knowledge into the firm.
Better prepared to face disruption	Interviewee believes collaboration with makerspaces can help firms cope with changing environment and thus avoid being disrupted.
Future insights	Interviewee believes makerspace collaboration can provide indicators of possible technological, environmental, and cultural developments.

Interdisciplinary areas of knowledge	Interviewee believes it is advantageous for firms to gain access to knowledge from a broad spectrum of disciplines through collaboration with makerspaces.
Knowledge of complementary technologies & services	Interviewee believes it is advantageous for Novozymes to gain access to knowledge about technologies and services complementary to Novozymes' core areas.
New areas of knowledge	Interviewee believes collaboration with makerspaces grants access to knowledge, which would otherwise not be attained by the firm.
Spotting trends early	Interviewee believes collaboration with makerspaces improves the firm's ability to spot and comprehend contemporary trends early.

Table VI. Elaboration of select concepts in: 'Makerspace characteristics'.

Concept	Explanation
Based on trust and freedom	Interviewee perceives makerspace relations as contingent on trust and freedom rather than formal structure.
Creative and inventive	Interviewee perceives makers as creative and inventive
Flat hierarchy	Interviewee perceives makerspaces as having a flat hierarchy devoid of formal power structures.
Interdisciplinarity	Interviewee perceives that makerspaces consist of participants with skill-sets in a wide array of disciplines
Many & diverse participants	Interviewee perceives the makerspace participants to be many and diverse in terms of demographic, social, and cultural parameters.
Open to working with firms	Interviewee believes makerspace participants are open to working with firms under the right conditions.
Openness - sharing knowledge & open participation	Interviewee perceives sharing knowledge and inclusiveness to be the core values of makerspaces.
Organically driven with no formal organization	Interviewee believes that makerspaces are not driven by rules or long-term commitments.
Reciprocity	Interviewee believes that reciprocating is an important premise for collaboration in makerspaces.
Varying participation	Interviewee perceives that regularity of participation may differ widely in makerspaces, as participants manage their available time.
Volatile makerspaces	Interviewee perceives makerspaces to be liable to change rapidly and unpredictably.

Table VII. Elaboration of select concepts in: 'Motivation'.

Concept	Explanation
Acknowledgement from peers	Interviewee believes that peers recognizing their contribution is a motivating factor for collaborating.
Building personal network	Interviewee believes the potential for establishing personal relations in makerspace networks is a motivating factor.

Enjoyment	Interviewee believes that working on projects that are fun and exciting is motivating.
Freedom	Interviewee perceives the freedom to be creative and work with whatever project they want, however they want is motivating.
Interest	Interviewee believes that working on projects that are interesting is motivating.
Job opportunities for makers	Interviewee believes that the potential for finding new employment through the network of makerspaces is motivating for makers.
Learning	Interviewee believes the potential for developing personal skillsets is a motivational factor for collaborating.
Management support	Interviewee believes that employees' motivation to working in makerspaces is contingent on managers supporting the idea.
New challenges & work context	Interviewee believes participants are motivated by the possibility of working with projects and processes that are different from their everyday tasks is motivating
Not motivated by money	Interviewee believes that participating in makerspaces is not motivated by prospects of monetary rewards.
Social	Interviewee believes that face-to-face social interaction is a motivational factor for working in makerspaces.
User needs	Interviewee believes that working on solutions that they need themselves is a motivational factor for makers.

Table VIII. Elaboration of select concepts in: 'Network benefits'.

Concept	Explanation
Extending reach	Interviewee perceives collaboration with makerspaces to be an opportunity for firms to increase the amount of people with whom they interact.
Many contributors	Interviewee believes that a large amount of people can contribute to collaboration between firms and makerspaces.
New opportunities for R&D	Interviewee believes collaboration between firms and makerspaces can open up new avenues for research and development through the extensive maker network.
Network access	Interviewee believes firms improve their access to maker networks through collaborating with makerspaces.
Global network	Interviewee perceives the network of makerspaces to which firms gain access through makerspace collaboration to be globally distributed.
Workshop participation	Interviewee believes that participating in the makerspace network can grant access and invitations to different workshops and conferences.

Table IX. Elaboration of select concepts in: 'Organizational benefits'.

Concept	Explanation

Faster innovation	Interviewee believes the innovation process of firms can be sped up by collaborating with makerspaces.
Mindset & culture benefit from openness	Interviewee believes that the mindset and culture of employees can benefit from being exposed to the new processes and tools of makerspaces.
Renewal	Interviewee perceives makerspace collaboration as a possible catalyst for renewing firm capabilities and knowledge base.

Table X. Elaboration of select concepts in: 'Firm characteristics'.

Concept	Explanation
Firm innovation driven by market needs	Interviewee perceives Novozymes as innovating in order to meet market demand and profit from the innovation.
Formal internal knowledge sharing	Interviewee identifies a formal system of knowledge sharing in Novozymes
Informal internal networks	Interviewee identifies an underlying informal system of knowledge sharing in Novozymes.
Internal homogeneity	Interviewee perceives knowledge bases and mindsets of employees in Novozymes as similar to each other.
Relatively closed tradition and culture	Interviewee perceives Novozymes as a traditionally introvert firm concerning locus of knowledge search.

Table XI. Elaboration of select concepts in: 'Strategic approach' and 'Uncertainty about the future'.

Concept	Explanation
Strategic integration	Interviewee perceives the integration of makerspace collaboration into the overall strategy of Novozymes to be an important agenda for the near future.
Value creation	Interviewee believes that there is an important strategic consideration in how makerspace collaboration can create value to Novozymes

Table XII. Elaboration of select concepts in: 'Strategic approach' and 'Uncertainty about the future'.

Concept	Explanation
Threat of disruption	Interviewee believes that Novozymes is under constant threat of being disrupted by unforeseen changes in technology and environment.

Appendix 2. List of all results including all concepts and categories

Table XIII All results from open coding of interviews with Novozymes employees

Categories & concepts	Number of mentions	% of total mentions within the category	% of total mentions in all categories
Barriers & challenges to collaboration	**154**		**17,05 %**
IPR & contract issues	32	20,78 %	
Prioritization of scarce resources	28	18,18 %	
Limited proof of concept	17	11,04 %	
Internal reluctance	15	9,74 %	
Lack of management approval	15	9,74 %	
Mindset used to internal problemsolving	10	6,49 %	
Incompatible with existing innovation process	10	6,49 %	
Commercial value not clear	10	6,49 %	
Prioritizing internal knowledge	4	2,60 %	
Understanding the new logic	3	1,95 %	
New paradigm	3	1,95 %	
Practical issues	3	1,95 %	
New capabilities required	2	1,30 %	
Makers' suspicious attitude towards firm intentions	2	1,30 %	
Knowledge benefits	**129**		**14,29 %**
Knowledge of complementary technologies & services	31	24,03 %	
Future insights	15	11,63 %	
Absorbing new inputs	15	11,63 %	
Interdisciplinary areas of knowledge	14	10,85 %	
New areas of knowledge	13	10,08 %	
Spotting trends at an early stage	10	7,75 %	
Better prepared to face disruption	9	6,98 %	
New capabilities	7	5,43 %	
Learning	7	5,43 %	
New applications for enzymes & new market opportunities	5	3,88 %	
Eradicate false-negatives	2	1,55 %	
Reabsorbing inventions	1	0,78 %	
Firm-makerspace relation	**100**		**11,07 %**
Firms should contribute to communities	19	19,00 %	
Engaging through active participation	16	16,00 %	
Establishing relations	12	12,00 %	
Knowledge sharing	10	10,00 %	
Learning by doing	10	10,00 %	
Collaboration	7	7,00 %	
Donation with no strings attached	6	6,00 %	

Mutual benefits	6	6,00 %	
Education	6	6,00 %	
Trust and authenticity	5	5,00 %	
Focus on the process	2	2,00 %	
Focus on product	1	1,00 %	
Network benefits	**85**		**9,41 %**
New opportunities for R&D	20	23,53 %	
Network access	11	12,94 %	
Social Impact	8	9,41 %	
New collaboration partners	8	9,41 %	
New context for collaboration	7	8,24 %	
Extending reach	6	7,06 %	
Many contributors	5	5,88 %	
Startups	5	5,88 %	
Global network	5	5,88 %	
Workshop participation	3	3,53 %	
Diffusing technology, knowledge & agendas	3	3,53 %	
Easy access to community	3	3,53 %	
Follow up project	1	1,18 %	
Firm characteristics	**84**		**9,30 %**
Firm innovation driven by market needs	20	23,81 %	
Open to external knowledge	10	11,90 %	
Informal internal networks	10	11,90 %	
Bureaucractic structure	9	10,71 %	
Close customer collaboration	7	8,33 %	
Relatively closed tradition and culture	6	7,14 %	
Formal internal knowledge sharing	6	7,14 %	
Internal Homogeneity	5	5,95 %	
Strength found in the ability to integrate knowledge	2	2,38 %	
Two firm innovation logics	2	2,38 %	
Firm innovation driven by technology	2	2,38 %	
R&D large part of the organization	2	2,38 %	
Empowered employees	2	2,38 %	
Social media for information gathering	1	1,19 %	
Makerspace characteristics	**62**		**6,87 %**
New innovation process driven by technology	10	16,13 %	
Many & diverse participants	8	12,90 %	
Organically driven with no formal organization	7	11,29 %	
Lowering technology costs	7	11,29 %	
Interdisciplinarity	5	8,06 %	
Radical approach	4	6,45 %	

Volatile makerspaces	4	6,45 %	
Production capabilities	3	4,84 %	
Creative and inventive	3	4,84 %	
Openness - sharing knowledge & open participation	2	3,23 %	
Users	2	3,23 %	
Flat hierarchy	2	3,23 %	
Varying participation	1	1,61 %	
Open to working with firms	1	1,61 %	
Embracing Failure	1	1,61 %	
Idealism	1	1,61 %	
Expertise and high competence	1	1,61 %	
Motivation	**56**		**6,20 %**
Interest	11	19,64 %	
Freedom	10	17,86 %	
Enjoyment	9	16,07 %	
Learning	8	14,29 %	
New challenges & work context	5	8,93 %	
Management support	4	7,14 %	
User Needs	4	7,14 %	
Job opportunities for makers	3	5,36 %	
Building personal network	2	3,57 %	
Governance of collaboration	**46**		**5,09 %**
Avoiding IPR issues	14	30,43 %	
Limited openness in practice	6	13,04 %	
Support from the firm	5	10,87 %	
Firm-hosted community	5	10,87 %	
Firm cedes control	4	8,70 %	
Different types of IPR	3	6,52 %	
Long tail of patents	3	6,52 %	
Keep project open	3	6,52 %	
Do-ocracy	3	6,52 %	
Organizational benefits	**43**		**4,76 %**
Mindset & culture benefit from openness	19	44,19 %	
Faster innovation	9	20,93 %	
Integrating new capabilities	7	16,28 %	
Renewal	6	13,95 %	
Recruiting	2	4,65 %	
Strategic approach	**35**		**3,88 %**
Strategic integration	12	34,29 %	
Value creation	10	28,57 %	
Support long term strategic goals	6	17,14 %	

New strategic dimension	5	14,29 %	
Structural integration	2	5,71 %	
Uncertainty about the future	**35**		**3,88 %**
Benchmarking	17	48,57 %	
Threat of disruption	14	40,00 %	
Global technology change	4	11,43 %	
Industry orientation	**35**		**3,88 %**
Competitors	11	31,43 %	
Competitiveness	6	17,14 %	
Public knowledge	5	14,29 %	
Causing disruption	5	14,29 %	
Industrywide benefits	4	11,43 %	
Firstmover	4	11,43 %	
Defining projects	**31**		**3,43 %**
Should not involve core areas of the firm	20	64,52 %	
Agree on project	4	12,90 %	
Common interests	3	9,68 %	
Goals & topics initially loosely defined	2	6,45 %	
Brainstorming & joint discussion	1	3,23 %	
Short projects to reduce complexity	1	3,23 %	
Firm vs. makerspace logics	**8**		**0,89 %**
Different approach to research and development	4	50,00 %	
Different organizational logics	2	25,00 %	
Untraditional partnership	1	12,50 %	
Separate identities	1	12,50 %	
Grand Total	**903**	**16,18 %**	**9,85 %**

Table XIV All results from open coding of interviews with makerspace participants

Categories & concepts	**Number of mentions**	**% of total mentions within the category**	**% of total mentions in all categories**
Makerspace characteristics	**232**		**38,16 %**
Organically driven with no formal organization	33	14,22 %	
Openness - sharing knowledge & open participation	31	13,36 %	
Many & diverse participants	21	9,05 %	
Varying participation	18	7,76 %	
Based on trust and freedom	15	6,47 %	
Reciprocity	15	6,47 %	
Interdisciplinarity	15	6,47 %	
Open to working with firms	13	5,60 %	
Encouraging participation & involvement	12	5,17 %	
Volatile makerspaces	10	4,31 %	
Flat hierarchy	8	3,45 %	
Expertise and high competence	7	3,02 %	
New innovation process driven by technology	7	3,02 %	
Idealism	7	3,02 %	
A minimum degree of rules needed to handle bad situations	7	3,02 %	
Lowering technology costs	4	1,72 %	
Creative and inventive	3	1,29 %	
Embracing Failure	3	1,29 %	
Radical approach	2	0,86 %	
Production capabilities	1	0,43 %	
Firm-makerspace relation	**84**		**13,82 %**
Individual relations	21	25,00 %	
Trust and authenticity	17	20,24 %	
Donation with no strings attached	11	13,10 %	
Knowledge sharing	9	10,71 %	
Focus on the process	9	10,71 %	
Firms should contribute to communities	6	7,14 %	
Mutual benefits	5	5,95 %	
Engaging through active participation	1	1,19 %	
Learning by doing	1	1,19 %	
Focus on the product	1	1,19 %	
Collaboration	1	1,19 %	
Establishing relations	1	1,19 %	
Education	1	1,19 %	
Motivation	**72**		**11,84 %**
Interest	16	22,22 %	

Learning	10	13,89 %	
Freedom	9	12,50 %	
Enjoyment	9	12,50 %	
Social	8	11,11 %	
Building personal network	6	8,33 %	
Acknowledgement from peers	5	6,94 %	
User needs	4	5,56 %	
Not motivated by money	3	4,17 %	
Teaching and spreading knowledge	1	1,39 %	
Job opportunities for makers	1	1,39 %	
Governance of collaboration	**47**		**7,73 %**
Do-ocracy	16	34,04 %	
Firm cedes control	8	17,02 %	
Keep project open	7	14,89 %	
Limited openness in practice	5	10,64 %	
Hackathon	4	8,51 %	
Avoiding IPR issues	4	8,51 %	
Long tail of patents	1	2,13 %	
Different types of IPR	1	2,13 %	
Firm-hosted community	1	2,13 %	
Network benefits	**45**		**7,40 %**
Workshop participation	8	17,78 %	
Global network	8	17,78 %	
Network access	7	15,56 %	
New collaboration partners	5	11,11 %	
Extending reach	4	8,89 %	
Many contributors	4	8,89 %	
Easy access to community	3	6,67 %	
Diffusing technology, knowledge & agendas	3	6,67 %	
New opportunities for R&D	2	4,44 %	
New context for collaboration	1	2,22 %	
Knowledge benefits	**41**		**6,74 %**
Interdisciplinary areas of knowledge	13	31,71 %	
Absorbing new inputs	11	26,83 %	
Learning	6	14,63 %	
New areas of knowledge	5	12,20 %	
Knowledge of complementary technologies & services	4	9,76 %	
New capabilities	1	2,44 %	
Future insights	1	2,44 %	
Defining projects	**35**		**5,76 %**
Goals & topics initially loosely defined	12	34,29 %	

Brainstorming & joint discussion	8	22,86 %	
Higher order purposes	5	14,29 %	
Common interests	5	14,29 %	
Short projects to reduce complexity	3	8,57 %	
Should not involve core areas of the firm	1	2,86 %	
Agree on Project	1	2,86 %	
Barriers & challenges to collaboration	**28**		**4,61 %**
Makers' suspicious attitude towards firm intentions	13	46,43 %	
IPR & contract issues	4	14,29 %	
Cultural differences	3	10,71 %	
Understanding the new logic	2	7,14 %	
Conflicts	2	7,14 %	
Incompatible with existing innovation process	1	3,57 %	
Practical issues	1	3,57 %	
Mindset used to internal problemsolving	1	3,57 %	
Limited proof of concept	1	3,57 %	
Organizational benefits	**9**		**1,48 %**
Mindset & culture benefit from openness	4	44,44 %	
Faster innovation	2	22,22 %	
Recruiting	2	22,22 %	
Renewal	1	11,11 %	
Firm vs. makerspace logics	**9**		**1,48 %**
Different organizational logics	5	55,56 %	
Different approach to research and development	3	33,33 %	
Separate identities	1	11,11 %	
Strategic approach	**3**		**0,49 %**
New strategic dimension	1	33,33 %	
Support long term strategic goals	1	33,33 %	
Strategic integration	1	33,33 %	
Firm characteristics	**3**		**0,49 %**
Firm innovation driven by technology	1	33,33 %	
Open to external knowledge	1	33,33 %	
Highly skilled employees	1	33,33 %	
Grand Total	**608**	**14,44 %**	**20,06 %**

Appendix 3. Interview Guides

The interview guides provided here are organized by the round in which the questions were asked. Overall, each interview centered around 3-5 themes. For each theme, we had devised a set of "stock" questions to choose from, should conversation stagnate. Most interviewees were talkative, however, and answered many these questions without us needing to ask them. We rarely decided to rein conversation in, as it was important to follow the notions of our interviewees as long as they stayed in the general vicinity of the topic of discussion.

Novozymes Employees Round 1

Strategi og innovationsprocesser

Hvordan ser Novozymes' innovationsprocesser ud?
Hvordan er Novozymes strategiske tilgang til åben innovation?
Hvad er de hidtidige resultater?

Ethanol sensoren

Hvem var med på projektet?
Hvordan blev kontakten til partneren skabt?
Hvordan blev projektet sat i gang?
Hvordan blev emnet besluttet?
Hvad var udfordringerne?
Hvad var udbyttet af samarbejdet?
Hvordan integreres den nye viden i Novozymes?
Hvordan er det blevet taget imod?
Hvad har Novozynes lært af samarbejdet?
Er der nogle planer om gentagne samarbejder i fremtiden?

Åbne samarbejder

Deltager Novozymes i åbne samarbejder?
Hvilke områder inddrages i samarbejder?
Hvilke former tager eksterne samarbejde?
Hvordan vælges eventuelle samarbejdspartnere?
Hvilke outputs ønsker Novozymes at opnå?
Hvad er de største fordele ved samarbejder?
Hvad er de største udfordringer?
Hvordan agerer jeres konkurrenter på dette område?

Integration af ny viden

Hvordan kan det integreres i Novozymes innovationsprocesser?
Hvordan er Novozymes struktur gearet i forhold til at integrere ekstern viden fra åbne samarbejder?
- Hvordan integreres ekstern viden fra samarbejder generelt i Novozymes?
- Hvad er den største udfordring ved at integrere viden udefra? Og hvordan håndteres/løses disse udfordringer?

Åbne samarbejder i fremtiden

Hvad er perspektiverne på samarbejder med makerspaces for Novozymes i fremtiden?
Hvad er strategien i forhold til åbne samarbejder?

Novozymes Employees Round 2 & 3

Kendskab til Makerspaces og do-it-yourself miljøer

Har du hørt om makerspaces eller hackerspaces?
- Hvis ja, hvad er de for en størrelse fra dit perspektiv?

Har du hørt om Novozymes' projekt med Labitat og Biologigaragen?
- Hvis ja, hvad tænker du om det?
- Hvordan er de nye ideer blevet taget imod i Novozymes?
- Kunne du forestille dig at I kunne lave samme type af projekt i jeres afdeling?

Åben innovation generelt

Hvilken holdning har du til åben innovation generelt?
Kan det skabe værdi? Hvis ja, hvordan?

Holdning til denne form for samarbejde og åben deling af viden i netværk

Hvad tænker du generelt om denne for for samarbejde i åbne fora med mange forskellige mennesker, hvor du ikke kan kontrollere hvad der sker med viden eller have rettigheder?

Hvad er din holdning til åben deling af viden i eksterne netværk?
Hvilke udfordringer tror du der vil være ved at indgå i disse åbne samarbejder med makerspaces?
- På organisationsplan?
- På individplan? For den enkelte ude i "spacet"?

Tror du denne form for samarbejde kunne foregå inde for samme business unit/afdeling eller skulle man oprette en særskilt afdeling?

Motivation til at indgå og deltage i samarbejde med de eksterne miljøer

Hvis du eller nogen fra afdelingen skulle ud og samarbejde med folk i makerspaces, hvad skulle der så til for at motivere dig/dem?
- Målsætninger?
- Struktur?
- Tryghed?

Hvad skulle der til for at du ville synes det var en god eller dårlig idé?
Hvordan ville du have det i en rolle som bindeled mellem det eksterne netværk og det interne? Hvor du er ude og arbejde på projekter i makerspaces og efterfølgende hjemme for at fortælle om det?
Hvilken tilgang ville du umiddelbart have til det?
Hvilke udfordringer ville der være?
Hvilke fordele kunne der være?
Hvilke karakteristika tror du der er vigtige hos de folk der evt. skulle ud og samarbejde med nye mennesker uden for Novozymes?

Integration af åbne samarbejder i virksomheden

Hvordan tror du at samarbejder med makerspaces og de åbne netværk kunne skabe værdi for Novozymes?

Hvordan kunne viden som man opnår ved samarbejdet integreres i Novozymes?

Hvordan ville det blive taget imod, hvis der var en som havde fundet noget viden ude i makerspaces og så kom hjem til afdelingen?

Hvordan kunne evt. modstand mindskes?

Påvirkning af innovationsprocesserne i Novozymes

Hvordan tror du at det kunne påvirke innovationsprocesserne i Novozymes?
Tror du det ville kunne bidrage med noget?
Hvad skulle der til for at det kunne skabe værdi?

Novozymes Employees Round 4

Strategi og innovationsprocesser

1. Hvordan ser Novozymes innovationsprocesser ud?
2. Hvordan defineres åben innovation i Novozymes?
3. Hvordan er Novozymes strategiske tilgang til åben innovation?
4. Hvad er de hidtidige resultater?

Makerspaces - fra et Novozymes perspektiv

1. Hvad er makerspaces for en størrelse fra et Novozymes perspektiv?
2. Hvilke områder kan inddrages i åbne samarbejder med makerspaces? [Kerneområder? Sekundære områder?]
3. Hvordan kan samarbejder med Makerspaces blive noget som skaber værdi?
    - Hvad kan makerspaces bidrage med som Novozymes ikke selv kan/har?
    - Hvordan kan det blive en ressource?
4. Hvilke outputs ønsker Novozymes at opnå? [produkter?, viden?, netværk?]
5. Hvilke kompetencer/ressourcer får Novozymes ud af at indgå i makerspace samarbejder?
    - Hvordan påvirker det Novozymes innovationskapacitet at etablere en relation til makerspaces og deres netværk?
6. Hvilke former kan samarbejdet tage?
    - Hvilken tilgang skal Novozymes have?
    - Hvordan kan man påvirke arbejdet i disse spaces?
    - Hvordan kan man styre arbejdet i en ønsket retning?
7. Er der forskelle på måden makerspaces arbejder på og den måde Novozymes arbejder på?
    - Hvad er udfordringerne ved disse? [kultur?, struktur?, innovationsprocesser?]
    - Hvad er generelt de største udfordringer ved at begynde at samarbejde med makerspaces?
8. Hvordan agerer jeres konkurrenter på dette område og hvilken betydning har det for jer?

Integration af ny viden

- Skal Novozymes udvikle nye kompetencer og resourcer for at indgå og få mest muligt ud af at samarbejde med makerspaces?
- Hvordan kan output fra et makerspace projekt integreres i Novozymes innovationsprocesser?
- Påvirker det Novozymes evne til at omstille og forny sig, at man indgår i samarbejde med makerspaces og deres netværk?
- Hvordan er Novozymes kultur gearet i forhold til at integrere ekstern viden fra åbne samarbejder?

- Hvordan er Novozymes struktur gearet i forhold til at integrere ekstern viden fra åbne samarbejder?
- Hvad er den største udfordring ved at integrere viden udefra? Og hvordan håndteres/løses disse udfordringer?

Makerspaces - samarbejder i fremtiden

- Hvad er perspektiverne på samarbejder med makerspaces for Novozymes i fremtiden?
- Hvad skal der til for at makerspaces vil være noget man satser på og integrerer i sin innovationsstrategi?
- Hvad skulle der til for at Novozymes åbnede sit eget makerspace?

Makerspace Participants Round 1

- Hvordan opstod og forløb samarbejdet med Novozymes?
- Hvilke typer samarbejder engagerer I jer generelt i?
    - Hvad søger i at opnå ved disse samarbejder
    - Hvad er spillereglerne for at indgå i samarbejde
- Hvordan ville holdningen være til et virksomhedsorganiseret makerspace?
- Hvad er motivation for at engagere sig i et makerspace?
    - Betyder anerkendelse fra andre makers noget?
    - Betyder anerkendelse fra virksomheder noget?
- Hvordan deles viden som opnås i et makerspace?
- Hvordan er relationen mellem offline og online netværk af makerspaces?
    - Hvad er værdien af netværket?

Makerspace Participants Round 2

Logics in a makerspace

- Describe the workflow at biologigaragen.
- Are there any rules (explicit or implicit)?
- What are the core values of BG?
- How are projects chosen?
- Can anyone join in and participate at any moment – as in; is there a point of development beyond which no newcomers can enter?

Projects

- Which projects are exciting and where do the ideas for these come from?
- How do you set your goals for individual projects, who sets them, and how are they evaluated?

Makers

- What are peoples' backgrounds and why do they come to the makerspace?
- Who are the most active? Is there a certain type?
- Lead User characteristics:
    - Do you participate in projects / create them in order to solve your own needs? Why (not)? Which?
    - Are there any other personal gains to be had from these projects?

- Does motivation stem from *using* products/knowledge afterwards, disseminating, or selling?
- Is biohacking a hobby on the side or a way to improve your work-related abilities?

Internal cooperation in the makerspace.

- How is work coordinated? Are there any structures? Processes?
  - Challenges of participating offline and online? Barriers? Advantages?
- How is the learning process in the makerspace?
  - How do you learn from each other?
- Is trust an issue? How is trust built between you both in physical and online spaces?
- What roles exist in the makerspace and how are these assigned?
  - Is there any form of hierarchy?
- What are the norms / cultures with regards to correcting / criticizing each other's work?
- What about adding to the work of others? Differences offline vs. online? Physical prototypes vs. software?
- What are the relations between people doing a project? After project end, what happens?

Network

- Describe the network of makerspaces?
- Is BG connected to an online network? How? Internal / external?
  - How frequent is interaction with online network vs. offline?
  - Does frequency of interaction depend of phases of a project? Online vs. Offline?
  - How is the network utilized?
- Do you visit other spaces?
- Pros and cons of being in a network?

Firm-hosted communities

- Firm hosted communities? Participation in such community attractive? Why/why not?
  - Would you go down to a NZ hackerspace and create with (/for) them?

Makerspace Participants Round 4

Logics i et makerspace

- Hvordan fungerer arbejdsgangen i biologigaragen?
- Er der nogle regler etc.?
- Hvilke værdier er centrale?
- Hvordan vælges projekter? Kan alle komme ind og deltage i projekterne? Er der forskel på i hvilken fase projektet er i forhold til åben deltagelse? Hvad hvis det f.eks. er gået i gang?

Projekter

- Hvilken projekter er spændende? Hvor kommer ideerne fra?
- Hvad er målene med et projekt? Hvilke typer af målsætninger er der?

Makers

- Hvad er folks baggrunde? Og hvorfor kommer de i makerspace?
- Hvilke typer af personer er mest aktive?
- Lead User karakteristika:
    - I hvilket omfang deltager I i projekter for at opfylde egne behov? Hvorfor? Hvilke behov?
    - Forventer i selv at få gavn af projekterne? Er der personlige fordele ved at udvikle et produkt?
    - Er ideer til projekter noget der stammer fra egne behov? Nye eller alment kendte behov?
    - Ligger motivationen i at *bruge* produkterne/viden bagefter eller i at *sælge* produkterne/viden

Samarbejde internt i makerspace

- Hvordan koordineres arbejdet i et makerspace? ER der nogle strukturer? Processer? Offline vs. Online?
    - Hvordan er opgaver/projekter fordelt/struktureret?
    - Udfordringer ved at deltage både offline og online? Barrierer? Fordele?
- Hvordan er læringsprocessen i et makerspace?
    - Hvordan lærer I af hinanden?
- Hvordan opstår/udvikles tillid mellem makers i det fysiske community og online? Er tillid et issue?
- Hvilke roller er der i et makerspace? Hvilke roller tager individer? Hvordan får de disse roller?
    - Er der nogen form for hierarki?
- Hvordan er kulturen/normerne i forhold til at finde fejl/kritisere hinandes arbejde? På samme måde bygge videre på/forbedre hinandens arbejde? Forskelle offline vs. online?
- Hvilke udfordringer er der i forhold til at arbejde videre på andre folks arbejde?
- Hvordan er relationerne mellem deltagerne på et projekt? Er de vedvarende eller stopper de når projektet stopper?

Netværk

- Hvordan er netværket af makerspaces?
- Er biologigaragen forbundet til et online netværk? Hvordan? Hvorfor/hvorfor ikke?
    - Hvor ofte interageres der med online netværk? Andre makers både offline og online?
    - I hvilke faser af et projekt er der mere eller mindre kontakt mellem maker og netværk? Online vs. Offline?
- Besøger I andre spaces?
- Hvad er fordelen ved at være en del at netværket? Ulemperne?
- Hvordan anvendes netværket? Online vs. Offline?

Firm-hosted communities

- Firm hosted communities? Participation in such community attractive? Why/why not?
    - Ville I tage tage ned og "make" hvis Novozymes oprettede deres eget åben makerspace? Hvad skulle der til?
- Betyder anerkendelse fra virksomheder noget i et makerspace/community?
- Betyder anerkendelse fra andre deltagere noget i et makerspace/community?

External Experts Round 1

Engagement

- Hvad er virksomheders motivation i forhold til at ville afstå fra rettigheder i åbne samarbejder?
- Hvad er det åbne communties kan tilbyde/bidrage med som virksomheden ikke selv har? Hvad er det typisk virksomheder leder efter?
- Hvad kan virksomhederne bidrage med som fællesskaberne ikke har?
- Hvordan kan man som virksomhed nærme sig og indgå samarbejder med åbne fællesskaber som makerspaces?

Execution

- Hvordan kan man forene makerspaces (åbenhed) og Novozymes (patenter)? Forene de 2 forskellige logikker?
- Hvordan kan tunge R&D virksomheder finde en balance mellem åbenhed og intern R&D?
- Hvilke faktorer påvirker graden af åbenhed?
- Hvilke faktorer påvirker åbenhed på henholdsvis virksomhedens kerneområder og sekundære områder?
- I hvilke dele af en typsik NPD proces kan man være mere eller mindre åben? Hvor i processen giver det bedst mening af være åben? Er der nogle stages der er bedre egnet til åbne samarbejder end andre?
- Hvordan "styres" åbne samarbejder når de ikke *kan* styres?
- Er der alternative former for beskyttelse (ud over IPR) som virksomheder kan benytte sig af? F.eks. Det at have makerspaces tættere på? Være først ude? Holde sig i spidsen af den teknologiske udvikling? Undgå disruption?

Effects

- Hvad er effekten af åbne samarbejder? Fordele?
- Hvilken slags viden kommer der ud af det?
- Hvordan kan åbne samarbejder som med makerspaces påvirke en virksomheds innovations output/performance?
- Hvilke fordele kan virksomhederne opnå ud over/som ikke er afhængig af IP? I forhold til kommercialisering?
- Direkte/indirekte benefits?

External Experts Round 2

Engagement

- Hvilke logikker gør sig gældende i en industri som bioteknologi?
- Hvilke logikker gør sig gældende i "the open source movement" inden for biologi?
  - Hvordan er de forskellige? Hvordan er de kontraster?
  - Er der nogen ligheder mellem open source software og open source biology?
- Hvad er virksomheders motivation i forhold til at ville afstå fra rettigheder i åbne samarbejder?
- Hvad er det åbne communties kan tilbyde/bidrage med som virksomheden ikke selv har?

    - Hvad er det typisk virksomheder leder efter?
- Hvad kan virksomhederne bidrage med som fællesskaberne ikke har?
- Hvordan kan man som virksomhed nærme sig og indgå samarbejder med åbne fællesskaber som makerspaces? (hvad er paradokset?)
- Hvilke faktorer påvirker graden af åbenhed?
- Hvilke faktorer påvirker åbenhed på henholdsvis virksomhedens kerneområder og sekundære områder?
- I hvilke dele af en typsik NPD proces kan man være mere eller mindre åben?
    - Hvor i processen giver det bedst mening af være åben?
    - Er der nogle stages der er bedre egnet til åbne samarbejder end andre?

Execution

- Hvordan kan man forene makerspaces (åbenhed) og Novozymes (patenter)?
    - Forene de 2 forskellige logikker?
- Hvordan kan tunge R&D virksomheder finde en balance mellem åben ekstern R&D og intern R&D?
- Hvordan "styres" åbne samarbejder når de ikke *kan* styres?
- Hvilke strategier for beskyttelse og kommercialisering kan virksomheder benytte sig af?
    - Er der alternative strategier for beskyttelse (ud over IPR) som virksomheder kan benytte sig af?
    - F.eks. Det at have makerspaces tættere på? Være først ude? Holde sig i spidsen af den teknologiske udvikling? Undgå disruption? Disrupte konkurrenter?

Effects

- Hvad er effekten af åbne samarbejder? Fordele? Ulemper?
- Hvilke direkte og indirekte benefits er der ved åbne samarbejder?
- Hvordan kan virksomheder indfange og integrere værdi fra åbne samarbejder?
- Hvilke faktorer påvirker værdiskabelsen?
- Hvad er de største barrierer eller udfordringer i forhold til åbne samarbejder mellem virksomheder og åbne communities?
- Hvilken slags viden kommer der ud af det?
- Hvordan kan åbne samarbejder som med makerspaces påvirke en virksomheds innovations processer/output/performance?
- Hvilke fordele kan virksomhederne opnå ud over/som ikke er afhængig af IP?
- I forhold til kommercialisering?

External Experts Round 4

Makerspaces

- Hvad er makerspaces for en størrelse?
- Hvad er styrkerne ved et makerspace?
- Hvad kan makerspaces og deres netværk bidrage med som virksomhederne ikke selv kan?

Engagement

- Hvordan kan virksomheder med en lukket forretningsmodel gribe et samarbejde an?
- Hvilken værdi får de ud af det? Hvordan det kan blive værdiskabende?
- Hvordan kan man måle dette?
- Hvordan kan det påvirke deres innovations kapacitet?
- Kan det hjælpe virksomheder til at forny sig?

Maker movement

- Hvad er trenden generelt for de her meget åbne miljøer og samarbejder?
- Er det en trussel for industrierne? Hvordan er det en trussel?
- Fremadrettet, hvilken et innovationsparadigme kigger vi så frem imod?
- Hvad bliver de største udfordringer for virksomhederne?