Open Innovation in a High-Tech R&D Environment: Critical Factors for Project Success

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Abstract

Organizations across different industries increasingly open-up their innovation processes (Chesbrough & Crowther, 2006). Open-innovation can deliver a positive contribution to organizations such as accelerating product cycle-time and reducing costs of product development. Moreover, organizations start to collaborate for sustaining competitive advantages and to efficiently respond to customer needs and new emerging markets.

This Master thesis project was focused on collaborative inter-firm project teams. These project teams are valuable because they reduce uncertainties by sharing costs and risks, diversify knowledge bases and joint problem solving (Husted & Michailova, 2010). However, despite of the advantages of open-innovation, collaboration problems arise. In particular when organizations collaborate, differences in organizational cultures, background knowledge and innovation objectives result in collaboration challenges and even collaboration failures. In fact, a French Community Innovation Survey (CIS) by Lhuillery et al. (2009) showed that 14% of R&D collaborations failed due to problems within partnerships. In addition, Kale et al. (2002) found that only 63% of inter-firm collaborations are successful.

Differences between organizations in collaborative projects play an important but underestimated role in the success of joint innovation. The collaboration challenges are based on the different inputs of organizations that affect the project team process and eventually project success. The current literature has hardly discussed operational challenges within collaborative projects, but is rather focused on the organizational level of inter-firm collaborations.

This master thesis aimed to identify the critical factors that influence project success in inter-firm R&D collaborations, based on a multiple case study. Interviews were conducted among 20 respondents participating in three currently deployed collaborative project teams in a high-tech R&D environment.

The results of this study showed that clear and shared innovation goals in inter-firm projects contributed positively to inter-disciplinary collaborations and in turn, to project success. Moreover, effective leadership was found to be essential to create clear and shared innovation goals. Additionally, an actively involved partner contributed to project progress and hence to better project results. Finally, partner residents (i.e. employees of industrial partners stationed within a project team) contributed positively to the knowledge sharing process.
Preface

This report is the result of my master thesis project, performed in partial fulfillment of the requirements for the degree of Master of Science in Innovation Management at the Eindhoven University of Technology, department Industrial Engineering and Innovation Sciences. This Master Thesis is conducted under supervision of dr. J.M.P Gevers (first supervisor), dr. S. Rispens (second assessor) and ir. H.W.H. De Groot (company supervisor). This research project has been performed in cooperation with Holst Centre Eindhoven.

First of all I would wish to thank Holst Centre Eindhoven for providing me the opportunity to conduct this research project in a business setting. This research project tried to explore a topic that received only limited attention in current literature, which made exploratory research in a business setting challenging. Although I conducted this research project on my own, contributions of my supervisors Josette Gevers, Sonja Rispens and Harmke de Groot were very helpful to complete this study. Therefore, a special thanks to Josette Gevers for the theoretical insights, guidance and extensive support, and Harmke de Groot for the practical insights, guidance and extensive support during my internship of six months at Holst Centre Eindhoven.

In addition, I would also like to thank all participants in this study, especially program managers and project leaders of the projects investigated at Holst Centre Eindhoven, who were very willing to cooperate in this study. Besides that, I would wish to thank all participated external organizations for their contributions in this study.

Finally, I would like to thank my relatives for their support during this Master Thesis project.

Ruud Emile Claessen

Eindhoven, the Netherlands, August 2012
Executive Summary

The open-innovation concept is widely used in organizations across multiple fields. Organizations open-up their innovative activities for exchanging internal and external knowledge (Chesbrough, 2003b). Within this open-innovation concept this study focuses on collaborative inter-firm R&D projects. Inter-firm collaboration projects are defined as two or more independent organizations interacting adaptively, interdependently and dynamically towards a common and valued goal.

Whereas open-innovation has multiple advantages such as reducing uncertainties by sharing costs and risks, diversifying knowledge bases and joint problem solving (Husted & Michailova, 2010), challenges do occur. In particular when organizations collaborate, differences in organizational cultures, background knowledge and innovation objectives result in collaboration challenges and even collaboration failures. The research objective of this Master thesis was to identify the critical factors that influence project success in collaborative projects in an open-innovation environment. Based on a prior literature study it can be concluded that the current literature hardly discusses team level challenges within inter-firm collaborations, but is more focused on the organizational level of inter-firm collaborations. Nevertheless, the literature suggested several organizational input factors that may influence inter-firm R&D collaborations. From literature it is not known which factors are most influential, and neither it is clear how i.e. through which team mechanisms, they influence project success. This results in the main research question:

How do input factors of collaborating partners influence inter-firm collaborative success in an open-innovation context?
In this study first a research model is developed as shown in Figure 1, based on initial findings in this study and fundamental teamwork models (i.e., the IMO-model of Mathieu et al., 2008 and the IMOI-model of Ilgen et al., 2005).

Second, the research model was used as framework for an exploratory research project based on a multiple case study. The data collection is based on open-ended interviews. The sample used for investigating the research question consists of 20 respondents from three currently deployed collaborative R&D project teams performing in a high-tech environment at Holst Centre.

The results of this study showed that several factors influenced project success in collaborative R&D projects at Holst Centre. These factors represented consortium composition factors, opportunities given and conditions set by the involved organizations in the project, and team composition factors, opportunities given and conditions set in the internal project team by Holst Centre. Based on the results three major conclusions are provided:

1. Clear and shared innovation goals in the project contribute positively to inter-disciplinary collaborations and in turn, to project success. Moreover, effective leadership is needed to have clear and shared innovation goals;
2. An active partner provides direction and guidance to the project and hence to better project success;
3. Partner residents contribute positively to the knowledge sharing process.
Based on the study findings a causal model (Figure 2) is proposed that represents the identified factors and their presumed relationships. Based on this causal model, eleven research propositions (Table 1) are formulated which may be used as a starting point for future research on inter-firm R&D collaborations.

![Figure 2, Causal model](image)

| Proposition 1.1 | Project success requires technological, business and partnership success. |
| Proposition 1.2 | An effective team process requires clear & shared project goals, trust and cohesion. |
| Proposition 1.3 | An effective internal team process contributes positively to project success. |
| Proposition 1.4 | Effective leadership contributes positively to an effective internal team process by creating project team cohesion, trust and clear & shared project goals. |
| Proposition 1.5 | Effective leadership contributes positively to shared innovation goals. |
| Proposition 1.6 | Shared innovation goals contribute positively to an effective internal team process. |
| Proposition 1.7 | The functional diversity in the project team contributes negatively to an effective internal team process initially. |
| Proposition 1.8 | Shared innovation goals and effective leadership reduce the negative relationship between functional diversity in the project team and effective internal team process which means that in that case, project success of diverse project teams is higher than of non-diverse project teams. |
| Proposition 1.9 | One or more active partners enforce the positive relationship of shared innovation goals on an effective internal team process. |
| Proposition 1.10 | Strong organizational autonomy & protective knowledge sharing have a negative relationship with an effective team process |
| Proposition 1.11 | Resident involvement reduces the negative relationship between strong organizational autonomy & protective knowledge sharing and an effective internal team process. |

Table 1, Research propositions
This study contributes to the existing team literature by providing insights on a special team type - inter-firm project teams. The conceptual model differs from earlier teamwork models in that multiple organizations provide input in the project team by consortium composition factors – which is a new concept proposed in this study. Additionally, this study contributes to the gap in the current open-innovation literature by identifying consortium composition factors that influence collaborative R&D, focusing on operational levels rather than organizational levels of open-innovation.

This study found that shared innovation goals in the overall project team and shared project vision supported by internal management are essential in inter-firm collaborative projects. Effective leadership in these project teams is necessary to achieve shared innovation goals and a shared vision that are support by all project members. This implies also that the project vision has to be aligned with internal management and all involved partners. In addition, active involvement of partners – preferably with contributions of partner residents - is essential to guide the project towards an application direction with clear requirements as this will enforce a shared innovation goal. These findings suggest three overall practical implications most important in collaborative projects in general and for Holst Centre specifically.

- Shared project vision and innovation goal by project team and higher management at both Holst Centre and the partner side is a necessary perquisite for project success;
- Effective leadership is essential to create and maintain shared vision and innovation goals supported by all involved stakeholders in the project; effective leadership consists of technical expertise in one domain to be respected by technical peers and the competence to create consensus on a shared project vision in the project between project team members and management of all partners, while being sensitive to cultural differences.
- Active partner involvement is a must, preferable with the contribution of residents.
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1. Introduction

The traditional view of innovation in industries is based on the assumption that organizations use internal knowledge, investments in R&D and the use of intellectual property (IP) mechanisms to achieve sufficient profitability (Wallin & von Krogh, 2010). This view is also referred to as the closed innovation model. This means that knowledge is kept internal and protected by IP in order to prevent competitors from using it. However, an increasing number of organizations over the past decade started to collaborate with customers and suppliers and other parties in the product and process innovation in order to sustain competitive advantage and efficiently respond to customer needs. This phenomenon is often referred as open-innovation (Wallin & von Krogh, 2010). Open-innovation can be defined as the purposive use of inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation (Chesbrough & Crowther, 2006). Open-innovation can deliver a positive contribution to organizations in accelerating product cycle time, reducing cost of product development, and improve product quality by using external expertise i.e. outside the company boundaries.

Although there are the many benefits following out of opening-up the innovation process, collaboration challenge also arise. The different organizational cultures, background knowledge and expertise in open-innovation projects might result in a beneficial outcome but often also result in conflicts and in the extreme cases to collaboration failures (Tidd, Bessant & Pavitt 2001). In fact, a French Community Innovation Survey (CIS) by Lhuillerya & Pfister (2009) showed that 14% of R&D collaborations failed due to problems within partnerships. In addition, Kale et al. (2002) found that only 63% of inter-firm collaborations are successful.

There are several determinates for cooperation failures as proposed by Lhuillerya & Pfister (2009). The major determinant in cooperation failures is partner type e.g. collaborating with competitors could enhance the knowledge base, because competitors often have corresponding product/process development demands, but on the other hand collaborating with competitors might result in less cooperative knowledge sharing process because organizations are anxious to disclose their knowledge to a competitor. In addition to the partner type, insufficient experience in partnerships is also a determinate of cooperation failures according to Lhuillerya & Pfister (2009). Previous experiences with partners can help to reduce cooperation failures, while little or no experience with a particular partner often result in a cooperation failure. In addition to the well-known and well-documented risk factors, a very interesting determinant of cooperation failures seemed to be overlooked, namely the process of collaborative knowledge creation at the project team level. In collaborative inter-firm projects effective collaboration is essential in order to create an appropriate output, but this collaboration may be hampered by many different aspects within the project team, resulting in cooperation failures. Surprisingly, collaborative knowledge creation within inter-firm projects teams have received only limited attention in current open-innovation literature (e.g., Du Chatenier et al., 2009; Husted and Michailova 2010; Staudenmayer, Tripsas & Tucci, 2005).

This Master Thesis project focuses on the internal collaboration process in inter-firm teams and
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aims to identify the critical factors that influence project success in inter-firm R&D collaborations. A multiple case study is conducted to identify these factors in collaborative projects in an open-innovation environment within the organization of Holst Centre Eindhoven. The outcomes of this study provide recommendations for current practice, for organizations in general and for Holst Centre specifically. Also, propositions for future research, specifically for an organization wide quantitative investigation of Holst Centre are provided. Additionally, based on the findings of the literature study prior to this Master Thesis project, it can be concluded that the current open-innovation literature hardly discusses team level challenges within inter-firm collaboration, but is more focused on the organizational level of inter-firm collaborations. Therefore, the academic goal of this project is to contribute to the current scientific literature by providing new insights into the team mechanisms in inter-firm collaborations.

Holst Centre is a high-tech independent open-innovation R&D center that develops generic technologies for Wireless Autonomous Sensor Technologies and Flexible Electronics. Holst Centre is founded by Imec (Belgium) and TNO (The Netherlands) with support from the Dutch Ministry of Economic Affairs and the Government of Flanders (Holst Centre Executive Report, 2010). Collaborative projects at Holst Centre consist of partners from multiple organizations, PhD-students and internal scientists. Collaborating partners turn the open-innovation theory into reality by leveraging each other’s talent and know-how in a well-structured and professional corporate R&D setting as visualized in Figure 3. The project outcomes (e.g., intellectual property) are shared on a non-exclusive basis between the program partners by customized agreements tuned to the needs and situation of each partner (Holst Centre Executive Report, 2010).

In the following the outline of this Master Thesis is described. First in chapter 2, the theoretical background of this study is discussed focused on the open-innovation concept, team and team collaborations, and teamwork in inter-firm collaborations. In addition, the conceptual model is developed. Thereafter, the report focuses on Holst Centre open-innovation environment by introducing research questions and the research model of this study in chapter 3.

Furthermore, chapter 4 describes the research methodology and chapter 5 will present the results of three investigated project teams within Holst Centre Eindhoven. Finally in chapter 6, the general conclusions of the study are discussed and a causal model of the findings is developed, including research propositions. In addition, the theoretical and practical implications are discussed, as well as the limitations and recommendations for future research. Also, a list with definitions of key words is provided in Appendix 1.
2. Theoretical framework

This chapter will discuss the current academic literature on collaborative inter-firm project teams. At first, the open-innovation concept is discussed and thereafter the team literature is discussed by exploring the fundamental teamwork models. Finally, teamwork in inter-firm R&D collaborations is further elaborated upon by identifying and explaining the input factors that could have an influence in collaborative projects.

2.1. The open-innovation concept

The innovation management literature argues that we currently face a new era of innovation, namely a new paradigm open-innovation in which organizations open-up their innovative activities for exchanging internal and external knowledge (Chesbrough, 2003b). The key feature of open-innovation is that the boundaries of the company become permeable. This implies that the company is not only dependent on internal knowledge, but also creates the opportunity to assess external knowledge by entering partnerships with other organizations e.g. pursuing a co-creation strategy. Open-innovation is a concept consisting of many forms and compositions which are together depicted in the broader concept of networked innovation as defined by Swan & Scarbrough (2005). Networked innovation occurs through relationships that are negotiated in an ongoing communicative process. The typical characteristics of network innovation proposed by Valkokari, Paasi & Luoma (2009) are:

- There is a specific purpose of collaboration;
- Multiple organizations are involved in the innovation, while the collaboration is seldom open for everyone;
- The collaboration covers both the knowledge transfer and the co-creation activities.

The concept of networked innovation is visualized in Figure 4. The openness and interaction of innovation systems is shown on a continuum from internal, via external and collaborative, to open-innovation.

![Figure 4, The continuum of networked innovation by Valkokari, Paasi & Luoma (2009)](image)

The left side of the arrow focuses on internal innovation in which organizations use internal knowledge, investments in R&D and the use of intellectual property mechanisms to achieve sufficient
profitability (Wallin & von Krogh, 2010), which is also referred to as the closed innovation model. In contrast, the right side of the arrow focuses on open-innovation, representing an inter-organizational exchange of ideas, knowledge and technologies for improving effectiveness, efficiency and to reduce risks in the innovation process (Wallin & von Krogh, 2010). Thus, open-innovation concept implies knowledge exchange between collaborating partners in order to improve their innovative capabilities. For example when IBM announced the first personal computer, MS-DOS (i.e. Microsoft) was used as operating system. IBM did not develop their own operating system, but implemented it from Microsoft who was more experienced with software rather than hardware like IBM. In this collaboration, they used each other expertise to develop a personal computer.

The focus of this study lies on the right side of the arrow shown in Figure 4, in particular on the open-innovation concepts developed by Chesborough (2003a) in which external sources or organizations are used as inputs in R&D projects i.e. inter-firm R&D collaborations. Inter-firm R&D collaborations are defined as two or more teams of independent organizations interacting adaptively, interdependently and dynamically towards a common and valued goal.

Adopting an open-innovation strategy might be in direct contradiction to behavior that was endorsed and allowed in the past (Mortara et al., 2009). For example, collaboration with other organizations must be endorsed throughout the organization, which requires direct involvement and participation of top management to achieve organizational changes (Mortara et al., 2009). Furthermore, departments may experience difficulties in opening-up to the external environment. They may experience a strong cultural clash in collaborations with other organizations and find it difficult to accept external knowledge also known as the Not-Invented-Here Syndrome (Mortara et al., 2009). Additionally in R&D partnerships, an organization has no control over partners, resulting mostly in a cultural difference between partners in collaborations (Badir, Büchel & Tucci, 2009). Thus, the organizational culture differences between organizations might lead to hurdles in inter-firm collaborations. In particular, these cultural challenges might be noticed at the project team-level in which intensive collaborations are necessary to achieve the project objectives.

2.2. Team and team collaboration processes

Currently, projects in organizations are mostly completed through teamwork, where employees work together in a team to achieve an objective beyond the capability of employees working alone (Marks, Mathieu & Zaccaro, 2001). The success of the teamwork depends not only on the expertise of team members and available resources, but also on the interaction of team members to achieve a team objective (Marks Mathieu & Zaccaro, 2001). The study of teams and team processes began in the 1950s and 1960s, and since then several definitions of teamwork have been offered (Salas, Burke & Cannon-Bowers, 2000). An often used definition is “a set of two or more individuals interacting adaptively, interdependently and dynamically towards a common and valued goal” (Salas et al., 1992). Team members are assigned to specific functions to meet the team objectives and a team often has a limited life-span (Salas, Burke & Cannon-Bowers, 2000). Additionally, the team process involves team members to interact with each other and also with their task environment (Marks Mathieu & Zaccaro, 2001).
2.2.1. Fundamental teamwork models

In the past (i.e., prior to 1996), literature was mainly focused on the effectiveness of teams using input-output processes (Ilgen et al., 2005). However, recently the focus is changed into mediating processes for explaining why inputs influence the team effectiveness (Ilgen et al., 2005). The classic model in the nature of team performance, where inputs lead to processes which in turn lead to outcomes is referred to as the Input-Process-Output model (IPO-model) (Hackman, 1987). The key assumption of the framework is that input states affect the group outputs by interactions among team members (Hackman, 1987). Many studies based on the IPO-model have observed the effect of input variables on subsequent behavior of team members, and team performance outcomes (Hackman, 1987). The input factors, such as team tasks, features and work context affect the team interaction processes which in turn affect the output (Hackman, 1987). The literature on team research has adopted extensively the IPO-model. However, the IPO framework lacks a clear conceptual clarity in the understanding of teamwork because there is no clear explanation of what team processes are and how do they influence the team outcomes (Marks, Mathieu & Zaccaro, 2001).

Thus, the IPO-framework is not adequate for current research on team characteristics (Moreland 1996). The IPO-framework is limited because the path from input to output seems to be single-cycle linear (Ilgen et al., 2005). Failures in identifying possible feedback loops in the IPO-framework result in new models that use outputs as inputs (feedback loop) for explaining future emergent states and team processes. Therefore, Ilgen et al. (2005) revised the traditional IPO-framework into Input-Mediator-Output-Input framework (IMOI-framework), where the ‘process phase’ is substituted by the ‘mediator phase’ for reflecting a broader prospective in mediation variables that influence team performance. The IMOI-framework consists of feedback loops like, team interactions lead to outcomes which in turn influence new team processes and emergent states down the line. Team processes are characterized as interdependent team activities that organize task work in team members’ pursuit of goals (Marks, Mathieu & Zaccaro, 2001). On the other hand, team emergent states are products of team processes (Marks, Mathieu & Zaccaro, 2001). More specifically, emergent states describe motivational, cognitive and affective states of teams (Marks, Mathieu & Zaccaro, 2001). An example proposed by Marks, Mathieu & Zaccaro (2001), is that teams with low cohesion (emergent state) may be less willing to manage existing conflict (the process), which in turn may create additional conflicts that decreases cohesion levels even further. Mathieu et al. (2008) identified eight emergent states that often arise in a team setting, as shown in Table 2.

<table>
<thead>
<tr>
<th>Emergent states:</th>
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<tbody>
<tr>
<td>1. Team confidence</td>
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<td>2. Team empowerment</td>
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<td>3. Team climate</td>
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<td>6. Cohesion</td>
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<td>7. Trust</td>
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<td>8. Collective cognition</td>
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Table 2, Team emergent states by Mathieu et al. (2008)
Team confidence (1) refers to a shared belief among project members that the project team is capable to be successful. Underestimation about the team potential might affect team performance or the belief to achieve team objectives.

Team empowerment (2) refers to the decision making in the project teams and is dependent on confidence of higher management to empower project team members for making those decisions. Project team empowerment will only succeed when there is a mutual trust between project members and higher management about responsibilities and authorities.

Team climate (3) is defined as “the set of norms, attitudes, and expectations that individuals perceive to operate in a specific social context” (Pirola-Merlo et al., 2002). The role of climate at the team-level is that team members’ understanding of a situation affects their behaviors and attitudes (Naumann & Bennett, 2002). This implies that the environmental climate might positively or negatively influences the team operations. Additionally, the literature suggests there are more climate dimensions, like safety and justice climate. A study by Zohar (2000) demonstrated that safety climate (4) significantly predicted time-lagged team accident rates, however this is not relevant within context of this study. Justice climate (5) is defined as “distinct group-level cognition about how a work group as a whole is treated” (Naumann and Bennett, 2002). For example, insufficient value recognition of project management towards the project team often affects their behaviors and attitudes in the project team.

Cohesion (6) is defined as “the commitment of team members to each other to achieve the team objectives” (Goodman, Ravlin & Schminke, 1987). Team cohesion seems to be essential in order to achieve results in collaborative projects. In collaborations with external organizations technical know-how is exchanged, which could create a tension field by sharing knowledge on the one hand and protecting knowledge on the other due to the high scientific and commercial value of knowledge. This could hamper the team cohesion.

Trust (7) is defined as the confidence and belief in other team members. Trust is an important factor in teams, because trust between team members might lead to better communication and information sharing. In particular in collaborative projects, trust between organizations might affect the intensiveness of information exchange. When trust is achieved, commitment of the involved parties and project members might increase. This could result in more efficient collaborations because the team members are dedicated to outcome of the collaboration.

Collective cognition (8) is intensively investigated as an emergent state in the team literature. Collective cognition consists of two underlying dimensions, namely shared mental models and strategic consensus as important factors in team effectiveness. Shared mental models, are defined as “an organized understanding or mental representation of knowledge that is shared by team members” (Mathieu et al., 2005). Strategic consensus is defined as “the shared understanding of strategic priorities among managers at the top, middle, and/or operating levels of the organization” (Kellermanns et al., 2005). Organizational diversities and project team diversities could result in challenges in achieving a collective cognition in the project, while shared mental models among team members could ensure more effective teamwork and a smoother decision making process. Furthermore, strategic consensus on project objectives among team members including external partners seems to be important. In this
study, no clear distinction will be made in examining shared mental models and strategic consensus. Instead the study is focused on the overarching factor, collective cognition i.e. a shared or common view among team members.

### 2.3. Teamwork in inter-firm R&D collaborations

This section will elaborate on the challenges that arise when adopting an inter-firm collaboration strategy. To start we focus on the project team-level. Team members from various departments might have different ideas about the product to be developed, and without a strategic team vision these team members might force the project in unintended directions (Sethy, 2000). The concept of vision within a project team is one of the important means to generate meaning to the project (Revilla & Rodriguez, 2011). R&D projects require that all team members must be aware of the project vision (i.e., objectives or goals) in order to internalize and support them (Revilla & Rodriguez, 2011). In order to create a successful innovation, project vision is particularly important when organizations strive for the highest level of knowledge exploitation. Organizations in an open-innovation setting are dependent on inter-organizational knowledge transactions to improve or extend their internal knowledge capabilities and commercialize their knowledge (Argote, McEvily & Reagans, 2003). Furthermore, R&D project teams are faced with a variety of environmental and situational challenges which affect the team process (Salas, Burke & Cannon-Bowers, 2000). In general, the uncertainty in terms of external environmental factors might cause unexpected outcomes and changes in the project team objectives. Team members should share a common view on the environmental situations in order to accomplish shared situational awareness to effectively respond to changing situations within project (Paris et al., 1999).

Inter-firm R&D collaborations perceive several challenges in order to be successful, such as: balancing their tension field of sharing knowledge on the one hand, and protecting knowledge on the other hand. Knowledge is a central dimension in this tension field of knowledge sharing and protection in the relationship between collaborating organizations (Bogers, 2011). In addition, Bogers (2011) points out that trust is an important factor in collaborations, because trust between organizations might affect the intensiveness of knowledge sharing. As mentioned, when trust is achieved, organizational commitment – strong dedication to the company performance- might also increase. This could result in a more efficient way of collaborating because the organizations are dedicated to outcome of the collaboration. Also, the technological distance i.e. differences in technological capabilities and achievements between organizations may also play in important role in collaborative projects. Issues might arise when technological levels of expertise differ between organizations (Bogers, 2011). Besides that, cultural differences i.e. differences in organizational policies and objectives might also influence collaborative projects (Bogers, 2011). Different organizational cultures, background knowledge and expertise in open-innovation projects might result in a beneficial outcome but often also result in conflicts and in the extreme cases to collaboration failures (Tidd, Bessant & Pavitt 2001).

Inter-firm collaboration challenges are based on the organizational inputs i.e. diverse
organizational inputs could influence the project team emergent states which in turn, affect collaborative project success positively or negatively.

2.3.1. Input factors in collaborative R&D projects

Inter-firm R&D collaborations are not only diversified in functional background (i.e. team composition inputs) but also diversified on organizational backgrounds by consortium composition inputs of organizations involved. Consortium composition factors are opportunities given and conditions set by the involved organizations in the project, while team composition factors are opportunities given and conditions set in the internal project team. Multiple input factors are found in the current open-innovation literature. These input factors are summarized in Table 3.

<table>
<thead>
<tr>
<th>Team composition inputs</th>
<th>Consortium composition inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Project team functional diversity</td>
<td>1. Organizational Autonomy</td>
</tr>
<tr>
<td>2. Team stability</td>
<td>2. Resource availability</td>
</tr>
<tr>
<td>3. Hierarchy</td>
<td>3. Innovation goal</td>
</tr>
<tr>
<td>4. Leadership</td>
<td>4. Knowledge sharing</td>
</tr>
<tr>
<td>5. Structural composition</td>
<td>5. Level of uncertainty</td>
</tr>
<tr>
<td>7. Geographical proximity</td>
<td>7. Organizational culture</td>
</tr>
<tr>
<td>8. Learning history</td>
<td></td>
</tr>
</tbody>
</table>

Table 3, Team composition and consortium composition inputs

2.3.1.1. Team composition inputs

The first team composition input factor is **project team functional diversity** (1). The product development literature points out that successful innovation relies heavily on inputs from different departments within the organization (Tang, 1998). Cross-functional teams have great potential, but are also known as one of the most difficult types of team to manage because the functional differences are a source of task conflict which influences team performance negatively (Carlile, 2002). Conversely, a meta-analysis by De Wit, Greer and Jehn (2012) showed that task conflicts influence team performance positively under certain conditions. Functional diversity in project teams might influence the internal team dynamics because diverse competences in the project team might lead to discussions contributing positively or negatively to project performance.

**Team stability** (2) is defined as the entry and exit rate of team members (Gilsing & Nooteboom, 2005). It is argued that a stable group is expected to be more likely to create a lock-in effect, or groupthink, in contrast with a flexible group (Du Chatenier et al., 2009). Team compositions in collaborative project can be dynamic because the involvement of internal members and external partners can change over time, depending on the project phase and project progress.

**Hierarchy** (3) refers to “the positions people take in the network and the division of power and control within an organizational entity” (Hoang & Antoncic, 2003). A study by Lee and Choi (2003) found a negative relation between a hierarchy and knowledge creation, were a strong hierarchy hampers a constant flow of communication and knowledge. Therefore, a challenge arises for collaborating organizations in terms of finding a good balance between being in control and out of control in the
Open Innovation in a High-Tech R&D Environment: Critical Factors for Project Success

Leadership (4) describes the way an innovation team is managed, coordinated and facilitated (Gieskes & Van der Heijden, 2004). Project leadership could play an important role in collaborative projects. The complexity of the technologies developed and the involvement of several parties with diverse expertise, demands effective management and coordination from project management in order to achieve project objectives.

Structural composition (5) refers to the kind of network necessary for successful open-innovation (Gilsing & Nootboom, 2005). It seems that the main reason of partners join in collaborative projects is the technology potential, although the involvement of other (competitive) partners in the project might also contribute to the decision to join a collaborative project – the network of partners involved in projects could be valuable to explore competitor’s objectives in the a project.

Functional composition (6) describes the team members roles in the project team because a healthy balance in team roles is an important determinant for project performance (Belbin, 1993). The functional roles of team members in the project might influence internal alignment on project goals and in turn, project performance.

Geographical proximity (7) describes the physical distance between project members, because this influence the way team members communicate and extract information from each other (Cross et al., 2001). Geographical proximity can be overcome by virtual meetings however, a small physical distance to enhance communication and coordination is recommended.

The final team composition input factor is learning history (8), which refers to the period of time that project members worked with each other prior to the actual collaboration (Bolhuis & Simons, 2001). Prior related interaction between the collaborating partners have a positive impact on team performance as partners already trust one another (Zollo, Reuer, & Singh, 2002). The learning history might result to a smoother collaboration process because the project members are aware of each other’s competences and way of working.

2.3.1.2. Consortium composition inputs

As mentioned before, consortium composition factors are opportunities given and conditions set by the involved organizations in the project. Consortium composition factors are important because in inter-firm collaborations, diverse inputs of partners might result in alignment challenges that could affect the project progress and in turn, project success. At first, organizational autonomy (1) is based on the degree partner researchers are allowed to make their own decisions about content of the innovation process without influences of partner management. It could be that power influences from higher management of partners influence the project direction which in turn, could hamper initial project goals.

Resource availability (2) refers to the degree to which team members have access to the necessary resources for performing their tasks successfully (Du Chatenier et al., 2009). The high-tech environment at Holst Centre and the nearby facilities in the region seemed to contribute sufficiently to the resources needed for development, rather than need for facilities of partners to develop technologies.
The **innovation goal** (3) describes the innovation objective i.e. the outcome of the R&D collaboration. Shared innovation objectives between collaborating parties might result in a smoother collaboration process because there is a mutual understanding on how to achieve the end-goal. Without shared goals, collaborations could be challenging and could influence project performance.

**Knowledge sharing** (4) between collaborating organizations could also be a challenge because innovative project teams typically operate in a competitive environment in which knowledge has a high scientific and commercial value (Du Chatenier et al., 2009). This competitive environment might hamper knowledge exchange of partners because competitors could be involved in the same project.

The **level of uncertainty** (5) refers to the risks in the project in developing the technology. The level of uncertainty is often high for all involved organizations because of the nonlinear or character of innovation processes (Zhang & Doll, 2001). Long-term development (e.g., 3 to 6 years) in a high-tech environment consists of technological and economic risks which are shared among parties involved in the collaboration.

The **learning future** (6) refers to the period of time project team members and partners collaborate in a project (Du Chatenier et al., 2009). Long-term collaborations are likely to empower the learning process (Haakansson & Snehota, 1995) and also might create more trust among team members which strengthens the partnership. Conversely, time pressures in an innovative environment, could force organizations to focus on short-term objectives. For example, investing in long-term collaborations might be preferable for one organization, while another organization prefers short-term collaboration to increase the possibility of a first mover advantage.

Finally, **organizational culture** (7) is suggested to have a possible influence in collaborative projects (Tidd, et al., 2001; Badir et al., 2009; Bogers, 2011). Different organizational cultures, background knowledge and expertise in open-innovation projects might result in a beneficial outcome but might also result in conflicts and in the extreme cases to collaboration failures (Tidd, Bessant & Pavitt, 2001). Additionally in R&D partnerships, an organization has no control over partners, resulting mostly in a cultural difference between partners in collaborations (Badir, Büchel & Tucci, 2009).

### 2.4. Conclusion

Inter-firm R&D collaborations face some major challenges in order to successfully complete a project. In fact, collaboration difficulties in inter-firm R&D project teams may play an important but underestimated role in the failure of R&D partnerships. The challenges are based on the different inputs of partner organizations that affect the team process and emergent states in the project. The current literature has hardly discussed team level challenges within inter-firm collaboration, but is more focused on the organizational level of inter-firm collaborations. This finding explains the gap in the current literature on inter-firm collaborative projects.

Husted and Michailova (2010), who are among the few discussing this topic, argued that collaboration occurs primarily at the individual level and that the success of R&D collaborations is therefore dependent on participation of individuals in the collaboration. Thus, successfully sharing knowledge is contingent on individual knowledge sharing efforts and behavior within the project.
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(Husted & Michailova, 2010). Inter-firm R&D collaborations require that individuals coming from different organizations coordinate and communicate effectively with one another to accomplish the R&D objectives (Staudenmayer, Tripsas & Tucci, 2005). Furthermore, external managers could play an important but underestimated role in an inter-firm environment, because top-down changes of the organizations involved could force the project in unintended directions.

Organizational diversity and the occurrence of underlying objectives to participate besides the overall project objectives could lead to collaboration difficulties and in the worst case scenario even to collaboration failures. The input factors discussed in current literature could play an important but underestimated role in collaborative R&D projects. This study aims to investigate which input factors are found to be important for determining the success in inter-firm collaborations in a high-tech R&D environment at Holst Centre, and through which teamwork mechanisms (i.e. team emergent states) this occurs.

2.5. Conceptual model

Based on the literature review in the previous section, we extended the IMO-model of Mathieu et al. (2008) and the IMOI-model of Ilgen et al. (2005) in a conceptual model to apply particularly to inter-firm collaborations (Figure 5).
This conceptual model is based on existing team literature on fundamental teamwork models. In addition, the input factors identified in the current open-innovation literature on collaborative R&D projects are included, as well as the emergent states identified in the team literature.

The inter-firm collaboration context consists of three distinct phases, namely the input, mediator and output phase. The input factors are divided in two types, consortium composition factors and team composition factors, which are included in the model to create an overall view of the variables. Holst Centre provides researchers of diverse disciplines for the internal project team, and manages and coordinates the collaborative project. Collaborating partners have the opportunity to place own researchers as residents in the internal project team.

Furthermore, the mediator phase displays the internal project team in which the identified team emergent states can arise. In the output phase, project success is strongly dependent on the team processes and emergent states that originate from the mediator phase. Additionally, according to the fundamental IMOI-model, project outputs are used as project inputs for explaining future emergent states in the project team (Ilgen et al., 2005), this explains the feedback loops in the conceptual model.

This conceptual model is used as a framework and is partially developed as part of the Master Thesis project within Holst Centre. This study contributes to theory-building on the one hand and theory-testing on the other hand. Theory-building aims to contribute to the existing literature on inter-firm R&D collaborations by using the conceptual model as guidance to elaborate on the practical findings, which in turn can be seen as theory-testing.

3. Research questions & research model

As discussed in the theoretical framework (chapter 2), the literature suggests several factors that might influence the inter-firm R&D collaborations. However, from literature it is not known which factors are most influential, and neither is it clear how i.e. through which team mechanisms, they influence project success. Therefore the research questions focus on input factors and mediators which determine project success as described in Table 4.

The first research question aims to identify the specific input factors in collaborative projects that have an influence on the project team and in turn, to project success. The second research question aims to identify the mediating factors that could explain the influence of input factors on project success.

<table>
<thead>
<tr>
<th>Main Research Question</th>
<th>How do input factors of collaborating partners influence inter-firm collaborative success in an open-innovation context?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Question 1</td>
<td>Which input factors influence project success in collaborative R&amp;D projects?</td>
</tr>
<tr>
<td>Research Question 2</td>
<td>Which mediators may explain the influence of input factors on project success in collaborative R&amp;D projects?</td>
</tr>
</tbody>
</table>

Table 4, Research Questions
After an initial orientation at Holst Centre and discussions with project leaders and program managers, the conceptual model in Figure 5 is revised into a research model as shown in Figure 6. Three emergent states appeared to be most recognizable. These emergent states are probably most influential in inter-firm project teams at Holst Centre. Therefore, these emergent states selected for further study. Additionally, the initial orientation resulted also in three project success dimensions that seemed to be most applicable in collaborative R&D projects within Holst Centre. However, the input factors in this research model are conducted from the interviews in this study and will be discussed in detail in chapter 5.

The research model consists out of three distinct phases, namely the input, mediator and output phase. The input phase consists of input factors of Holst Centre and its partners, external organizations contributing in the project. The input factors are divided in two types, factor 1 to 4 are the identified consortium composition factors in this study, while factor 5 and 6 are the identified team composition factors in this study. The accumulation of consortium composition factors e.g. different organizational cultures or innovation goals, have an influence on the mediator phase. The mediator phase consists of three team conditions – also referred to as emergent states - evolved in the life-cycle of the teamwork. These project team conditions have an influence on project success. Technological, business and partner success constitute the main dimensions of project success in the output phase.

![Figure 6, Research model](image)

The first four consortium composition factors are innovation goals (1) which refers to the project direction and objectives shared with partners involved in the project. Knowledge sharing (2) denotes the degree of sharing information from partners to the project team. Partner culture (3) refers to the practices and values of the partner organization, while partner autonomy (4) in this study denotes
the top-down power influences of partner management in the project teams. Finally, the team composition factors functional diversity (5) denotes to the diverse expertise of project members and leadership (6) refers to the way project teams are managed and coordinated. It seems that effective project leader contributes to a large extend in achievement of shared innovation goals among all parties involved. Additionally, three emergent states influence project success. At first, the project team cohesion i.e. the commitment of project team members to one another in achieving the project goals is perceived as a challenge. Second, trust is important in exchanging information between organizations involved, due to the highly competitive environment. Finally, the creation of shared goals in projects is sometimes hampered due to the involvement of multiple partners and also due to the background diversity of team members. Thus, shared goals, trust and cohesion seems to be very important for an effective team process.

Furthermore, in initial discussions with project leaders, it was argued that the achievement of technical objectives and deliverables is major determinant of project success. Looking at the hierarchical perceptions on project success, project leaders tend to describe the achievement of technical objectives as the most important factor, while higher management tend to describe partner satisfaction and the involvement of new partners as the most important factor. In addition, bilateral revenues and costs during the project life-time are also important to guarantee a sustainable business. However, an important note is that these dimensions are closely related to each other. For example, the partnership satisfaction might increase when project objectives are achieved and the technology is relevant for a potential application. A detailed description of the project success dimensions and the measurement of these dimensions is provided in section 4.1.3.2.

The research model is built on the fundamental teamwork models of Mathieu et al. (2008) and Ilgen et al. (2005). According to their fundamental IMOI-model, project outputs are used as project inputs for explaining future emergent states in the project team (Ilgen et al., 2005). In the context of inter-firm project teams, the feedback relationship from output to input only occurs on specific factors. Unsatisfactory outputs of a project could result in actions of Holst Centre on all consortium composition factors to influence the project processes positively e.g., changing the innovation goal or cope better with partner cultures. Also partners may take actions for better knowledge sharing e.g. improve communication by placing a resident, or even modify their innovation goal in correspondence with the project team. Nevertheless, partners cannot take actions on the other consortium composition factors because partners cannot change their internal organizational culture and autonomy to improve project outcomes. In fact when results are unsatisfactory, partners could withdraw from the project. Therefore it is important that Holst Centre monitors the outcomes and satisfaction level of partners to take corrective actions if necessary. Additionally a feedback loop exists towards team composition factors, where unsatisfactory outputs of a project could result in actions of Holst Centre such as changing a project leader. Furthermore, project outcomes result in a feedback loop that positively or negatively influence emergent states of the internal project team. For example, satisfactory outcomes could create more trust and team cohesion in the project team resulting in better internal collaborations to achieve subsequent goals, while unsatisfactory results might decrease trust and team cohesion.
4. Research Methodology

4.1. Research design

This section describes the research design for investigating the research questions proposed in Chapter 3. In correspondence with Holst Centre we decided to focus on an explorative study on collaborative R&D projects. The research model developed in the previous section is used as a starting point for this study. This explorative study can be seen as retroductive approach, were a theoretical framework in addition with relevant findings in practice creates an understanding of the situation (Poole et al., 2000). This is also in line with the descriptive framework approach proposed by Yin (1994), were data is collected and analyzed based on the relevance of a pre-determined descriptive framework.

In order to make a qualitative assessment of the challenges in collaborative projects, a multiple case study is conducted. The data collection is based on open-ended interviews with multiple project team members e.g. project leaders, internal team members and external stakeholders in order to collect a wide range of information to create an understanding of the occurring challenges. The sample used for investigating the research question consists of three currently deployed collaborative projects in different phases of execution from recently started to almost finalized.

4.1.1. Context of analysis

Holst Centre is an independent research centre and provides a neutral ground for R&D collaborations located at High Tech Campus Eindhoven. Holst Centre acts as an initiator and facilitator for joined development projects to generate new ideas and exchange knowledge to successfully bring a new technology to the market. Projects are usually initiated by Holst Centre and partners may be involved from the start or join in a later stage. Projects often have a long-term development focus (e.g., 3 to 6 years) which implies that partner involvement may change during the project. Project teams within Holst Centre consist of a mix of partners from different organizations, PhD-students and Holst Centre’s researchers, which are the majority of the project team.

Holst Centre implements the so called resident model, meaning that Holst Centre employees form the core of the research project, while industrial partners can station employees (residents) within a project team. This implies that the project is managed by project leader of Holst Centre. However, this does not mean that the project leader has full control over residents, because they are managed by their parent organization as well. Additionally, not all partners of a project will have a resident. Industrial organizations can also absorb project information without placing a resident on a daily basis in a project team.

4.1.2. Unit of analysis

The sample used for this study consists of three currently employed inter-firm R&D teams performing in a high-tech environment within the psychical boundaries of Holst Centre. In correspondence with Holst Centre we selected three project teams which differ on project phase, technology and project goals. The in-depth investigation on these diverse project teams provides a solid basis for the validation of the conclusions. Characteristics of the projects investigated in this study are
provided in Table 5. In project team A, the technology is in a transition phase from research to collaborative development with potential partners. Project team B, is currently in the functioning phase meaning that multiple technological achievements have been booked in which partners collaborate. Finally, project team C reaches its finishing phase in which the technology is transferred to partners. Project members within Holst Centre can operate on several projects at the same time, in this study two project members of project B also operated in project C.

<table>
<thead>
<tr>
<th>Project Teams</th>
<th>Nr. of project members</th>
<th>Project Phase</th>
<th>External partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
<td>17</td>
<td>Transition phase</td>
<td>-</td>
</tr>
<tr>
<td>Project B</td>
<td>20</td>
<td>Functioning phase</td>
<td>2</td>
</tr>
<tr>
<td>Project C</td>
<td>25</td>
<td>Finishing phase</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5, Project Characteristics

The organizational management structure for a technology program is shown in Figure 7. A technical program within Holst Centre is supervised by a Program director. Technical programs normally consist of several work packages (WP’s), supervised by one or more program managers dependent on their discipline. The program manager maintains partner contacts by regular meetings and updating and revising technical documentation. The project teams that will be investigated in the Master Thesis project operate in work packages. The daily supervision of WP’s at the operational level is done by project leaders. The responsibility of project leader is to meet the deliverables and milestones set by the program manager and to coordinate and monitor the progress of the team on a daily basis.

Figure 7, Organizational structure

The team composition as well as the partnerships can change when the technology evolves. In addition, it is important to note that all project teams are inter-disciplinary because R&D on high-tech technologies needs different areas of expertise.
4.1.3. Data collection procedure

The data collection procedure is based on open-ended interviews conducted among project members and external parties of three selected projects teams. Project success dimensions are not investigated by open-ended interviews, but are investigated separately to avoid a common method bias.

4.1.3.1. Interview design

Based in the findings in literature it is known that input factors affect emergent states in a positive or negative way which in turn, influence project success. The design of the interview questions is intended to identify the factors that influence project success. This is accomplished by designing open-ended questions focused on emergent states that appeared to be most recognizable in inter-firm project teams at Holst Centre i.e. cohesion, trust and shared goals in the project team, as shown in Figure 6.

The open-ended interview provide the opportunity to ask follow-up questions and let respondents elaborate on these questions. As a result, factors that could play a role are detected based on the answers of respondents on emergent states in the project. Thus in fact, relevant input factors are identified based on a careful analysis of the interview responses. The interview provided in Appendix 2 consists of five sections as shown in Table 6.

<table>
<thead>
<tr>
<th>Section 1</th>
<th>Demographics</th>
<th>Information of the respondent and the interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 2</td>
<td>Project team information</td>
<td>Elaborates on the objectives in the project, the role of the respondent in this project and the current project phase</td>
</tr>
<tr>
<td>Section 3</td>
<td>Project deliverables</td>
<td>Shared project objectives internally and externally in the project</td>
</tr>
<tr>
<td>Section 4</td>
<td>Project relationships</td>
<td>Questions on emergent states: relationships between different discipline groups and the relationships with external partners</td>
</tr>
<tr>
<td>Section 5</td>
<td>Finalization</td>
<td>Wrap up and room for additional questions</td>
</tr>
</tbody>
</table>

Section one focuses on the demographics, section two opens up the interview with some questions about the project, which gives an immediate impression about the respondent’s vision on the project. The third section elaborates on the shared project objectives perceived by the respondent. Furthermore, section four is the core of the interview. The questions are all related to emergent states that could occur in the project team. Follow-up questions can be asked by the interviewer to grasp the meaning of respondents in detail. Finally, the interview is ended with some general questions on project conflicts that could have occurred in the project and the definition of project success as perceived by respondents.

4.1.3.2. Project success dimensions

Project success in collaborative R&D within Holst Centre consists out of three dimensions, as discussed in chapter 3.

- Technological success: Value (potential) of the technology.
I. Scientific achievements: publications and conference proceedings to prove the scientific value of the technology;
II. Intellectual property: approved patents and patent applications to prove the novelty of the technology;
III. Technological project objectives: achievement of the initial project objectives and prove of academic claims.

- Business success: bilateral revenues during the life-time of the project in comparison with the internal resource costs of the project consisting out of 3 categories:
  I. Category 1: (Revenues/costs) x 100% > 100% ; less costs than revenues results in profit;
  II. Category 2: (Revenues/costs) x 100% > 50% ; costs more than revenues;
  III. Category 3: (Revenues/costs) x 100% < 50% ; costs more than twice the revenues.

- Partnership success: external involvement in the project makes it successful, due to the fact that partners create revenues. Therefore, partnership satisfaction needs to be realized to assure further involvement in the project by renewing or extending contractual agreements.

Information about the project success dimensions is collected as shown in Table 7. Information about the technological success is collected by an interview with the program manager and validated with the program director. The program manager monitors closely the technological progress of the project. Therefore, the program manager can provide information about the project achievements compared with initial objectives as documented in technical annexes. In addition, documentation on the scientific and IP value is examined to create an impression of the technological value potential of a project.

Project information about the revenues and costs is collected from the program director by an interview. Finally, partnership satisfaction is examined by using the partner evaluation survey results, which is a survey among all partners conducted by Holst Centre every year. The documentation of the survey results gives an objective interpretation about the satisfaction level of the partners.

<table>
<thead>
<tr>
<th>Success dimension</th>
<th>Source</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Technological success</td>
<td>Program manager</td>
<td>Documentation</td>
</tr>
<tr>
<td>2. Bilateral revenues/costs</td>
<td>Program director</td>
<td>Interview</td>
</tr>
<tr>
<td>3. Partnership satisfaction</td>
<td>Partner evaluation Survey 2011</td>
<td>Documentation</td>
</tr>
</tbody>
</table>

Table 7, Project success dimensions measurement

4.2. Interview analysis

The analysis of the interviews conducted was based on interview recordings and interview notes from the interviewer. The analysis procedure of the interview data was as follows. At first, the digital recordings and notes were written down in a text document for every respondent individually. Second, the interview responses were examined in-depth to discover factors that influence emergent states of the project team. Besides that, factors discovered were compared with the input factors found in literature.
Third, the factors identified and their influence on specific emergent states were saved in a data-base per project team. Hereafter, comparisons were made between project team members – a factor was considered relevant for this study when it was mentioned by at least two respondents in the same project. Thereafter, the results (Chapter 5) were discussed for each project individually and validated by quotations of respondents. Also, the results were visualized using graphs for clarity and transparency. Finally, comparisons were made between the projects teams selected, and conclusions were drawn.

5. Results

This chapter will present the results of the interviews conducted among 20 respondents coming from three different projects at Holst Centre. First, the general findings of the interviews will be discussed and thereafter, the results will be further discussed for each project individually.

5.1. General findings

The interviews revealed that several factors influenced the project success in collaborative R&D projects at Holst Centre. These factors are found by examining the interview responses on questions about the emergent states that occurred during the project, a factor was considered relevant when it was mentioned by at least two respondents in a project. The relative importance of a factor found is based on the number of respondents who elaborated on that specific factor. This number is divided by the total number of respondents in the project to calculate the percentage of respondents that referred to a particular factor.

The results for project A, B and C are shown in Figure 8, the left-hand side shows the results for consortium composition factors that could be mentioned by the respondents of complete project including external parties, and the right-hand side shows team composition factors that could be mentioned only by the internal project team members. Out of the six factors found in the interviews, four factors were frequently mentioned in the interviews, namely innovation goal, organizational culture, knowledge sharing and functional diversity of project team.

![Figure 8, Relative importance of factors found in projects A, B and C](image)
The innovation goal was frequently mentioned by respondents as a factor in projects A and B but did not occurred in project C. The innovation goals in project C seemed very clear, which explains why it was not mentioned by respondents. The organizational culture was a frequently mentioned factor in projects B and C but did not occur in project A. The partner culture played a role in projects B and C because partners were involved in these projects, while there was no partner involvement in project A. This explains why the partner culture was not mentioned by respondents in project A.

The factor knowledge sharing was mentioned in all three projects. Although there was no partner in project A, information was exchanged with potential partners. Project team functional diversity was a factor mentioned by all internal project teams. This implies that the diversity of team members played a role in all projects, which will be discussed for every project later on in this chapter.

Furthermore, two factors found were less frequently mentioned in the projects, namely organizational autonomy and leadership. Organizational autonomy was only found in project B and not mentioned in project C, which could imply that autonomy was not seen as a negative factor in project C. In project A no partner was involved which explains why autonomy of the partner was not mentioned. Leadership was only mentioned in project A, which could imply that there leadership was not a factor of influence in projects B and C.

5.2. Project A

5.2.1. Project information

In project A, a technology is developed for monitoring physical or environmental conditions by measuring volatile vapors. The major advantage of this technology is detecting conditions with a high sensitivity and limited power consumption. The small-scale technological system could be valuable for a wide range of potential applications that would be difficult or more expensive to realize using (larger) wired systems. Project A is currently in the transition from the research phase (developing core technology) to application oriented development in which promising applications are investigated.

Project A consists of 17 members in total: 11 internal operational members, 4 external members and 2 internal managerial members. The organizational structure of project A is shown in Figure 9.

![Figure 9, Project A organizational structure](image-url)
The internal project team consists of 11 operational members from Holst Centre (i.e., members from three discipline groups and the project leader). The internal project team benefits from a multi-disciplinary approach with competences from three discipline groups (i.e., Sensors & Energy harvesters, Ultra-low power Digital and System Integration) who collaborate intensively to develop the technology, assisted by the project leader who is responsible for operational activities such as progress reporting, delivering technical notes and planning activities. Additionally, the project consists of 4 external members (i.e., four suppliers). Several technical activities were outsourced to suppliers, whereas there is also one ‘potential’ partner in this project. This implies that the partner is not actively involved in the development of the technology in project A but shows interest in the technology by providing some general application ideas which were investigated by the project team. Furthermore, the project is managed by a program director and a program manager.

This project has two types of team meetings at the operational level, both bi-weekly. The first meeting is with the project leader and two discipline groups. The second meeting is with the project leader and the other discipline group. This implies that separate meetings are planned depending on the group’s expertise. Additionally, smaller meetings were held to discuss technical content more in detail with relevant members from specific discipline groups. These meetings occurred often on an ad hoc basis.

The successfulness of project A was examined by three project success dimensions. At first, technological achievements from an intellectual property prospective showed that one patent was realized. Additionally, from a scientific prospective, 12 publications with an average impact factor\(^1\) of 2.5\(^2\) for conference proceedings and 2.1\(^3\) for journal rankings was achieved. The project objective was to develop a miniaturized system that detects and distinguishes vapors with low power consumption. Over the past four years, the feasibility of the technology was proved and one initial demonstrator was developed which can detect certain volatile vapors. The current challenges are finding optimum design parameters and making them robust, and improve the read-out. Although feasibility of the technology was proved, the maturity of the technology in terms of robustness and reproducibility is still an issue to prove all initial academic claims. The second dimension, bilateral revenues versus the costs during the life-time of the project showed that the project was in category 3\(^4\), meaning that the costs were larger than twice the revenues. Finally, the partnership satisfaction could not be measured because currently there is no active partner contributing in the project.

To conclude, the technological achievements prove the technology concept but a mature technological system, useful for shared development with partners was not achieved. This implies that the technical progress is not sufficient to attract partners. Business-wise the project is not successful, revenues are low and no partner actively contributed in project A.

\(^1\) Impact factors generally higher in technology field of project A compared to technology field of project B and C.
\(^2\) Holst Centre internal conference ranking calculation
\(^3\) http://admin-apps.webofknowledge.com/JCR/JCR
\(^4\) Category 3: (Revenues/costs)\(\times100\%\) < 50\%
5.2.1.1 Sample size project A

Interviews were conducted with seven participants of project A, including four operational members from Holst Centre and one program manager of Holst Centre forming the internal project team, and two external respondents: one potential partner and one supplier. The respondent’s functions are showed in Table 8.

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational members (4)</td>
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</tr>
<tr>
<td>Discipline group 1</td>
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</tr>
<tr>
<td>Discipline group 2</td>
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<tr>
<td>Discipline group 3</td>
<td>1</td>
</tr>
<tr>
<td>Project leader</td>
<td>1</td>
</tr>
<tr>
<td>Program Management (1)</td>
<td></td>
</tr>
<tr>
<td>Program manager</td>
<td>1</td>
</tr>
<tr>
<td>External members (2)</td>
<td></td>
</tr>
<tr>
<td>External (potential) partner</td>
<td>1</td>
</tr>
<tr>
<td>External supplier</td>
<td>1</td>
</tr>
<tr>
<td>Internal project team n=5</td>
<td></td>
</tr>
<tr>
<td>Overall project team n=7</td>
<td></td>
</tr>
</tbody>
</table>

Table 8, Respondents project A

5.2.2. Results project A

The analysis of the respondent data resulted in four major input factors that influenced project success in project A, as shown in Figure 10. Innovation goal (71%) is most often mentioned as a factor of influence followed by knowledge sharing (43%), as argued by representatives of the overall project team. Leadership (60%) is most frequently mentioned followed by project team functional diversity (40%), as argued by representatives of the internal project team.

5.2.2.1. Factor 1: Innovation goal

Project A was very challenging due to the immaturity of the technology. The insight partner in project A argued that the project was still in a research phase, which made it difficult to evaluate the potential of the technology and to provide a specific application direction.

About 71% of the respondents indicated that the innovation goal was a factor that negatively
influenced project success in project A, and indicated that the project direction and objectives were not clear. Not having a shared innovation goal hampered the creation of a shared vision on project goals and priorities in the project team.

It was argued by three out of four operational respondents that having an active partner included in project A, would have led to a clearer application direction. Internal goals were set to develop the technology further to attract partners’ interest. However, operational members felt that these internal goals were not shared because the goals were not aligned between program management and operational members. One respondent formulated it as “without active involvement of a partner, it was difficult to achieve internal alignment about the direction to achieve the project goals”. Without partner involvement, alignment on internal goals was challenging.

5.2.2.2. Factor 2: Leadership

Project A was initiated by one discipline group who developed the core technology. Project management contributed intensively in this particular discipline group next to the responsibilities of coordinating and managing the overall project.

About 60% of the internal project team respondents indicated that leadership (i.e., the way the project is managed and coordinated) was a factor that influenced project success in project A. Leadership issues decreased the level of trust in achieving shared project goals within the project team, which in turn negatively affect the project team cohesion.

According to two out of four operational respondents that were interviewed, the fact that management was not independent negatively affected the alignment of priorities among discipline groups, which decreased the level of trust on prioritizations in the project. In fact, the respondents argued that the leadership role was not clear in project A, because project management contributed in a discipline group in which they prioritized their own research objectives. For example, whereas one discipline group supported by program management argued that further development of core technology should be first priority, other discipline groups argued that a technology demonstrator should be first priority because it was a means to show the functionality of the technology to attract partners. Operational respondents claimed that there was no internal alignment on prioritizations in the project which decreased the project team cohesion.

Additionally, two out of four operational respondents claimed that there was an unclear team structure without defined authorities and responsibilities. Operational respondents felt that there was no transparent interface for discipline groups to achieve alignment on the project direction and internal shared goals. Illustrative was that program management argued that overall group meetings were not valuable – “the technological progress was too marginal and therefore not useful as input for the other groups”. Therefore, separate meetings with discipline groups and program management were conducted, which seemed to contribute to the impression of an unclear team structure.

The intense involvement and participation of program management in some subgroup, but not in other groups produced conflicting responsibilities for project management, obstructed a clear team structure and undermined support for prioritization choices in the project.
5.2.2.3. Factor 3: Project team functional diversity

Three internal expertise (discipline) groups in project A contributed to the development of the technology. Although one discipline group initiated the project and developed the core technology, inter-disciplinary collaboration was essential to achieve project progress.

About 40% of the internal respondents indicated that the functional diversity (i.e., different expertise of project members) was a factor that influenced project success in project A. According to them, functional diversity hampered the project team cohesion.

According to two respondents that were interviewed, different opinions of discipline groups about the strategic direction created friction among internal members and hampered the project cohesion. For example, it was argued by one discipline group that a demonstration of the technology to partners should be second priority, while other discipline groups argued that demonstrations are means of showing the functionality of the technology and should be first priority, creating friction in the project team. These respondents argued that this friction was caused by the background expertise of the discipline groups. Internal alignment on the project direction was a challenge because the diverse background expertise influenced their vision on the technology. Functional diversity hampered internal alignment on project goals. This implies that the functional diversity in project A had a negative influence on the project team and influences project progress negatively, which is also suggested in a study by Carlile (2002).

5.2.2.4. Factor 4: Knowledge sharing

There was no active partner involvement in the development of the technology in project A. However, one potential partner showed interest in the technology by providing some general application ideas which were investigated by the project team.

About 43% of the respondents indicated that knowledge sharing (i.e., the degree of sharing application know-how from partners to project members) was a factor that influenced project success in project A as it affected the trustworthiness of the technology.

According to two internal respondents that were interviewed, the potential partner had difficulties in disclosing specific application details because the technology was not matured, and it was felt like potential partners did not completely trust the technological achievements so far. This finding is also argued by Bogers (2011) because trust is a major determinant in the intensiveness of knowledge sharing. In fact, one respondent mentioned that only vague specifications were provided which did not contribute to a clearer project direction and application goals - “It was hard to guide the project without clear specifications from the application point of view of partners”. The potential partner respondent argued that specific knowledge could not be shared because there was no collaboration agreement and the project was still in a research phase were the technological potential for applications needed to be further investigated.

Additionally, the same two internal respondents argued that information exchange was dependent on the contact person or department at the partner side because it decreased the effectiveness of communication. Illustrative was that initial communication with the potential partner occurred by interacting with their internal research department, who were not eager to provide
application ideas because they perceived Holst Centre as a competitor. This made information sharing between the potential partner and the project team challenging. Therefore, communication from project A to the partner was shifted to the partner’s business divisions. This seemed to improve the interaction with the potential partner because the business divisions perceived Holst Centre as a complementary institute rather than competitor.

Information exchange for application ideas was perceived to be hampered by lack of information sharing of partner contacts. Also, extraction of application ideas from potential partners was limited because the technical achievements so far were not convincing enough.

5.2.3. Conclusion project A

The four factors (i.e., innovation goal, knowledge sharing, project team functional diversity and leadership) were all perceived to have influenced project success. In particular, the innovation goal and leadership were most often mentioned as factors by the respondents in project A.

More specifically, there were no clear shared goals in project A. Without active involvement of a partner, the project was forced to pursue a technology push strategy by setting internal objectives for particular application areas to attract partners. Also, the immaturity of the technology made it difficult to provide a clear vision towards project goals that were shared internally. The technical progress and achievements lagged behind because there was no specific application goal. An application direction initiated by a partner was argued as essential to provide clearer direction. The leadership role and team structure was not clear because the project management was not independent in the project. This resulted in a lack of internal alignment on project direction and objectives resulting in issues that negatively affected trust and project team cohesion.

Additionally, functional diversity and knowledge sharing were less frequently mentioned as influential factors by respondents. Nevertheless, respondents perceived that functional diversity complicated the inter-disciplinary collaborations in project A. The differences between of the discipline groups created frictions on the alignment of internal project goals, which negatively affected trust and project team cohesion. This finding is also pointed out by the study of Carlile (2002) who argued that functional diversity could be a source of conflicts. Additionally, knowledge sharing with potential partners was challenging because partners perceived difficulties in disclosing specific application details because of the immaturity of the technology.

Thus, leadership issues and lack of shared goals seemed to enforce increased diversity challenges in the project team, and hampered project’s success. Indeed, compared to other projects, less technological and business success was achieved in the last year of development.

From a business prospective, project A was not successful, because there were bilateral costs and no revenues (i.e., category three) during the life-time of the project due to the fact that no partners were involved in project A. It seemed that the immaturity of the technology also contributed to internal challenges which in turn, made it difficult to provide a direction in the project for achieving technical success without contributions of a partner. Partners seem to be essential not only for business success, but also to guide the project towards an application direction with clear requirements as this will enforce a shared goal.
5.3. Project B

5.3.1. Project information

In project B a technology was developed for realizing the wireless communication of small, energy efficient radios. The major difference between current available radio solutions was the broadband carrier wave. This has three distinct advantages, namely interference robustness, elimination of signal fading and the opportunity for localization. In addition, the radio technology can be used for streaming of high quality audio around the body area network. The objective of project B is the development of a disruptive radio technology with low power consumption and medium data rates suitable for small applications with advantages over current consumer technologies. Project B is currently in the functioning phase, meaning that deliverables and milestones have been planned and form the base of the current project focus.

Project B consists of 20 members in total: 14 internal operational members, four external members and two internal managerial members. The organizational structure of project B is shown in Figure 11.

![Figure 11, Project B organizational structure](image)

The internal project team consists of 14 operational members from Holst Centre (i.e., members from three discipline groups and the project leader). The internal project team benefits from a multi-disciplinary approach with competences from three discipline groups (i.e., Wireless, Ultra-low Power Digital and System Integration) who collaborate intensively to develop the technology, assisted by the project leader who is responsible for operational activities such as, progress reporting, delivering technical notes and planning activities. Additionally, the project consists of four external members i.e. two partners and two suppliers. Several technical activities were outsourced to suppliers, while the partners were involved in different ways in project: one active heavyweight partner i.e. a partner involved in several technological programs within Holst Centre, for dedicated development and in parallel, one partner who was more passively involved by only monitoring the technological progress. There are however, no partner residents who contribute in the internal project team, but partners received updates and sometimes visited the project team for face-to-face meetings. Furthermore, the
project is managed by a program director and a program manager.

General team meetings are held bi-weekly supervised by the project leader. In these meetings the progress and planning and business prospects are discussed. The meeting is intended to inform internal operational team members about the status of the project and keep them on the right track. In addition, smaller meetings were held to discuss technical content more in detail with relevant members from specific discipline groups. These meetings occurred often on an ad hoc basis initiated by the project leader.

The successfulness of project B was examined by three project success dimensions. At first, technological achievements from an intellectual property prospective showed that one patent was realized and nine patent applications are pending. Additionally, from a scientific prospective, 32 publications with an average impact factor of 2.3\(^5\) for conference proceedings and 3.1\(^6\) for journal rankings were achieved. Over the past years many components of the technology have been realized e.g., fist worldwide prove of a demonstrator with full radio functionality, ear-to-ear and long distance communication. Most initial objectives were achieved, however the power consumption has to decrease further to prove all academic claims. The second dimension, bilateral revenues versus the costs during the life-time of the project showed that the project was in category three\(^7\), meaning that the costs were larger than twice the revenues. Finally, the partnership satisfaction survey\(^8\) showed that one partner rated a seven out of ten in terms of satisfaction with Holst Centre in 2011, were an eight was seen as complete satisfaction and a six as meeting expectations. The other (heavyweight) partner did not collaborate in this survey because of their company policy.

To conclude, project B was successful from a technological and partner prospective. A lot of technical progress has been booked and the partner was satisfied with the achievements. However, business-wise the project is not successful because revenues are too limited.

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\(^5\) Holst Centre internal conference ranking calculation

\(^6\) [http://admin-apps.webofknowledge.com/JCR/JCR](http://admin-apps.webofknowledge.com/JCR/JCR)

\(^7\) Category 3: (Revenues/costs)\(^\times\)100\% < 50\%

\(^8\) Holst Centre Partnership Evaluation Survey 2011
5.3.1.1. Sample size project B

Interviews were conducted with eight respondents of project B, including five operational members from Holst Centre and one program manager of Holst Centre forming the internal project team, and two external respondents: one partner and one supplier. The respondent's functions are showed in Table 9.

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of Respondents</th>
</tr>
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<td>1</td>
</tr>
<tr>
<td>Discipline group 3</td>
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</tr>
<tr>
<td>Project leader</td>
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<td>Program Management (1)</td>
<td></td>
</tr>
<tr>
<td>Program manager</td>
<td>1</td>
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<td>External members (2)</td>
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<td>External partner</td>
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</tr>
<tr>
<td>External supplier</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 9, Respondents project B

5.3.2. Results project B

The analysis of the respondent data resulted in five major input factors that influenced project success in project B, as shown in Figure 12. Organizational culture (75%) and innovation goal (63%) were most often mentioned as factors of influence in the project by representatives of the overall project team while project team functional diversity (67%) was frequently mentioned by representatives of the internal project team.

5.3.2.1. Factor 1: Organizational Culture

In project B, two partners were involved in the development of the technology, which implies that different organizational cultures merged in the development process.

About 75% of the respondents indicated that the partner culture (i.e., the practices and values of the partner organization) was a factor that influenced project success in project B. Partner culture hampered the creation of shared goals and influenced the project team cohesion.
According to one managerial respondent and two operational respondents that were interviewed, the culture of the heavyweight partner is characterized as very dominant i.e. highly influential. This hampered the achievement of a shared goal in project B because a large amount of effort went towards the achievement of deadlines set by the heavyweight partner. In fact, it was argued by two out of five operational members that the dominant culture of the partner resulted in additional requests, leading to additional dedicated efforts directed to the heavyweight partner. This was confirmed by the other partner because the partner respondent mentioned that “the priorities in the project seemed more directed to another partner”. Thus, due to the dominant culture of the partner, internal efforts were directed to the heavyweight partner, respondents felt that there was no shared goal in project B.

Additionally, the intention of the heavyweight partner was to achieve their own objectives. This created tension in the project team which resulted in a decrease in project cohesion in achieving shared goals. Illustrative was the situation in which the partner was very resolute in pushing their own objectives about the use of a particular component in the project, which resulted in intensive discussions between the partner and project team.

Project members perceived difficulties in realization of shared goals because the dedicated goals of the dominant partner distracted the achievements of shared goals. Even though, a large amount of technical results were booked in this project.

5.3.2.2. Factor 2: Project team functional diversity

Three internal expertise (discipline) groups in project B contributed to the development of the technology. Although, one discipline group initiated the project and developed the core technology, inter-disciplinary collaboration was essential to achieve project goals.

About 67% of the respondents indicated that the functional diversity (i.e., different expertise of project members) was a factor that influenced project success in project B. Functional diversity hampered trust among project members and the project team cohesion.

According to three respondents that were interviewed, accepting standpoints on technical content from other project members was sometimes difficult, resulting in intensive discussions. This hampered the level of trust among project members because opinions were not acknowledged. In fact, it was argued by four respondents that this was largely influenced by the background expertise of members in the discipline groups. Although, internal discussions between discipline groups were sometimes valuable for achieving internal alignment on project goals, the interviews revealed that internal discussions were often perceived as challenging because of diverse opinions on technical content between discipline groups.

Additionally, two out of five operational respondents mentioned that the value recognition between discipline groups was insufficient, which they felt as hampering the project cohesion because the project contributions were not always recognized. In fact, one operational respondent mentioned that “there was a tension field between two discipline groups about who receives the credits for a particular achievement”, which implied that there was a need to perceive value recognition among discipline groups. Moreover, program management argued that due to the diverse backgrounds of team
members, value recognition among discipline groups was sometimes challenging.

Whereas the background differences of discipline groups were perceived as challenging for project members, the technological progress of the project was successful. This finding implied that the intensive discussions between discipline groups could be experienced as uncomfortable by project members, while it eventually results in alignment for achieving the project goals and in turn, technical progress.

5.3.2.3. Factor 3: Innovation goal

Program management made agreements with one heavyweight partner for more dedicated application development.

About 63% of the respondents indicated that although there was a shared innovation goal, the separate application goals of the heavyweight partner was a factor that hampered the creation of a shared goal as well as the project team cohesion.

According to three out of the five operational respondents, the heavyweight partner set extremely high standards for the application deliverables, which they felt counteracted in the achievements of shared goals for the entire project. In fact, it was argued by two of the five operational respondents that these high standards of the partner affected the project transparency on the direction towards shared innovation goals. One of the respondents mentioned that there was “a short-time focus on upcoming deadlines and goals without a clear project vision”. Thus, because large amounts of effort went toward the dedicated partner goals, operational members felt that the overall project vision became unclear. Illustrative of this was that the fact that, when asked about the major objectives of the project, operational members described ‘technical objectives’ as most important, whereas program management described ‘dedicated application objectives’ as most important.

Additionally, operational members felt that the requirements of the heavyweight partner influenced the project cohesion because the direction in achieving shared innovation goals differed between operational members and program management, creating a distance between them. In fact, three out of five operational members argued that the planning for the application deliverables was too ambitious and unrealistic, whereas program management argued that the ambitions of the partners were to a large extent in line with the internal goals.

Although the realization of shared goals was hampered by the dedicated application goals of the heavyweight partner by operational members, technical progress was achieved. Dedicated goals resulted in project progress but this was not perceived as such by operational members. This implies that the priorities (i.e. dedicated vs. shared goals) were not clearly communicated which created an unclear vision in project B, this also explains the different view on project objectives between operational members and program management.
5.3.2.4. **Factor 4: knowledge sharing**

Two partners were involved in different ways project B, one heavyweight partner for dedicated development and in parallel, one partner who only monitored the technological progress. About 50% of the respondents indicated that knowledge sharing (i.e., the degree of sharing know-how from partners to project members and vice versa) was a factor that influenced project success in project B. Knowledge sharing hampered the achievement shared goals in the project team. According to one partner in project B, it was difficult to share know-how with project members because competitors could be involved in the project, which was felt by the project members as an impediment in the creation of *shared project goals*. This finding is also suggested by Lhuillerya & Pfister (2009) who argued that organizations are anxious to disclose their knowledge to competitors in collaborative projects. Moreover, it was argued by two internal respondents that knowledge was shared mostly one-way (i.e., from project team to partner), resulting in minimal feedback from the partner. The interviews revealed that this created the impression among project members that the partner was not very committed to project B. However, the partner respondent argued that project members broadcast large amounts of technical information, which was difficult and time-consuming to process. The partner respondent mentioned “there is no FTE available to process all information, therefore information was reviewed by multiple employees”. As a consequence, the overall vision and progress of the project was unclear for the partner due to the overload of technical details. Thus, the partner was not eager to share know-how due to competitive and information processing issues, project members felt that the partner was not committed in the achievement of shared goals.

Additionally, two internal respondents argued that it was sometimes better to delay results of preliminary outcomes before sharing it with the heavyweight partner. The interviews revealed that sharing of preliminary results caused more feedback from the heavyweight partner which hampered the achievement of initial deliverables. Therefore, one respondent argued to “avoid preliminary high expectations of the partner, until the development is crystallized out and partner feedback can be answered completely”.

Project members perceived challenges in information exchange because on the one hand, minimal information sharing from a partner hampered the achievement of shared goals and on the other hand, intensive partner feedback influences the information sharing protocols.

5.3.2.5. **Factor 5: Organizational autonomy**

Although, no partner residents were involved in the project B, partner researchers of the heavyweight partner sometimes visited the project team for face-to-face meetings and technical demonstrations.

About 25% of the respondents indicated that the partner autonomy (i.e., power influences of partner management on their researchers) was a factor that influenced project success in project B. Partner autonomy influenced the trustworthiness of the technology.

According to two respondents that were interviewed, the influence of partner management was noticed in face-to-face meetings with partner researchers because the *confidence* by partner researchers on the technological progress was overruled by partner management. The interview
revealed that in face-to-face meetings with partner researchers, initial achievements were seen as satisfying. However, after a certain period of time other technical targets were set by partner management. Project members felt that partner management had less confidence in the technological progress, while partner researchers were satisfied initially.

Top-down changes from partner management forced the project in another direction, even though partner researchers were satisfied with the initial achievements.

5.3.3. Conclusion project B
The five factors influenced project success by affecting the emergent states in the project team. In particular organizational culture, project team functional diversity and innovation goal were most often mentioned as factors by the respondents in project B.

The organizational culture in project B refers to the dominant culture of one heavyweight partner. The technological success dimension showed that a large amount of technical results were booked during this project. This implied that although there were internal challenges due the culture of the partner, project success was not hampered. This finding suggested that the partner culture and the high standards set contributed to project success, even though this resulted in some internal challenges among project members during the project. This is in line with the findings of Tidd et al. (2001) in which organizational culture may have a positive as well as negative influence on the project. Additionally, the functional diversity in project B was notable by the inter-disciplinary technology development. Whereas the background differences of discipline groups created intensive discussions on technical content which affected the emergent states in the project, the technological progress of the project was successful. This finding implied that the intensive discussions between discipline groups could be experienced as uncomfortable by project members, while it eventually (i.e., during the evolvement of the project) results in alignment for achieving the project goals. It might be that discussions are necessary for achieving technical progress and in turn, project success. The third factor was the dedicated application goals of the heavyweight partner and only partly shared innovation goals. On the one hand, dedicated development created an unclear vision of project members towards the overall innovation goal, on the other hand technical progress was booked because of the application direction initiated by the heavyweight partner. Thus, although the project goals were not shared, a partner can provide a direction to the project to achieve technical results.

Additionally, less frequent mentioned factors were knowledge sharing and partner autonomy. The different nature of involvement of the partners resulted in differences in sharing knowledge. Finally, the internal autonomy of the partner was noticed in the project team. Even if partner researchers were satisfied with the achievements, potentially top-down changes on the partner side forced the project in another direction.

These five factors influenced the internal project team dynamics by creating multiple internal challenges. However, this finding was not necessarily negative for project success based on the technical achievements that were booked and the partnership satisfaction. In fact, it seemed that internal challenges were sometimes helpful for better collaborations, although this is not perceived as such by internal members. However, from a business prospective, project B was not successful because the
bilateral costs were larger than twice the revenues (i.e., category three) during the life-time of the project. This could imply that partners paid relative small amounts for the knowledge perceived (which was satisfactory) or more partners were needed to make the project economically feasible.

5.4. Project C

5.4.1. Project information

In project C, a radio technology is developed that enables ultra-low power consumption, while still supporting high data rates. This advantage makes the technology valuable for integration in a wide spectrum of applications. The objective of this project is to design a communication system for wireless body area network applications with a specific power consumption target. Project C has a development history of three years and evolved significantly, therefore this project reached its final phase of development.

Project C consisted of 25 members in total during the life-time of the project: 20 internal operational members, three external members and two internal managerial members. The organizational structure of project C is shown in Figure 13.

The internal project team consisted over the project life-time of 20 operational members (i.e., members from three discipline groups and the project leader). In addition, three partner residents contributed in the project team and are therefore also considered as operational project members. The internal project team benefits from a multi-disciplinary approach with competences from three discipline groups (i.e., Wireless, Digital and Integration) and residents who collaborate intensively to develop the technology, assisted by the project leader who is responsible for operational activities such as, progress reporting, delivering technical notes and planning activities. Additionally, the project consists of external members, were several technical activities were outsourced to three suppliers. Also, partners were involved in different ways in project: one ambitious heavyweight partner focused on application development and in parallel, one heavyweight partner who monitored the technological progress and examined the technological potential. Furthermore, the project is managed by a program director and a program manager.

General team meetings are planned bi-weekly and supervised by the project leader. In these meetings the progress, planning and business prospects are discussed. This meeting is intended to
inform everybody about the status of the project and keep team members on the right track. In this meeting residents can join and discuss their challenges with other team members. In addition, smaller meetings were held to discuss technical content more in detail with relevant members from specific discipline groups. These meetings occurred often on an ad hoc basis.

The successfulness of project C was examined by three project success dimensions. At first, **technological achievements** from an intellectual property prospective showed that six patents were realized and six patent applications are pending. Additionally, from a scientific prospective, 35 publications with an average impact factor of 2.2\(^9\) for conference proceedings and 1.4\(^{10}\) for journal rankings were achieved. Over the past years many components of the technology have been realized e.g., technology demonstrator, application demonstrator and several generations of the technology are developed and measured. The objectives of the project were achieved which resulted in a mature technology suitable for transfer to partners. System evaluation takes currently place for the last generation of the technology and thereafter the project will be finished. The second dimension, **bilateral revenues versus the costs** during the life-time of the project showed that the project was in category two\(^{11}\), meaning that the costs were larger than the revenues, but at least half of the costs were covered. Finally, the **partnership satisfaction** could not be examined because both partners did not participate in the survey\(^{12}\) because of their company policy.

To conclude, project C was successful from a technological prospective. A lot of technical progress has been booked. Business-wise the project was successful because revenues were covering reasonably more than 50% of the costs. Additional revenues came from funded projects and Dutch government income.

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\(^{9}\) Holst Centre internal conference ranking calculation  
\(^{10}\) [http://admin-apps.webofknowledge.com/JCR/JCR](http://admin-apps.webofknowledge.com/JCR/JCR)  
\(^{11}\) Category 2: (Revenues/costs) \times 100\% > 50\%  
\(^{12}\) Holst Centre Partnership Evaluation Survey 2011
5.4.1.1. Sample size project C

Interviews were conducted with seven participants of project C, including five operational members from Holst Centre and one program manager of Holst Centre forming the internal project team, and one external supplier. The respondent’s functions are showed in Table 10.

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational members (5)</td>
<td></td>
</tr>
<tr>
<td>Discipline group 1</td>
<td>1</td>
</tr>
<tr>
<td>Discipline group 2</td>
<td>2</td>
</tr>
<tr>
<td>Project leader</td>
<td>1</td>
</tr>
<tr>
<td>Resident</td>
<td>1</td>
</tr>
<tr>
<td>Program Management (1)</td>
<td></td>
</tr>
<tr>
<td>Program manager</td>
<td>1</td>
</tr>
<tr>
<td>External members (1)</td>
<td></td>
</tr>
<tr>
<td>External supplier</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 10, Respondents project C

5.4.2. Results: Project C

The analysis of the respondent data resulted in three major input factors that influenced project success in project C, as shown in Figure 14. Organizational culture (71%) followed by knowledge sharing (57%) were most often mentioned as a factor of influence in the project by representatives of the overall project team while project team functional diversity (50%) was mentioned by representatives of the internal project team.

5.4.2.1. Factor 1: Organizational Culture

In project C, two heavyweight partners were involved in the development of the technology, which implied that different organizational cultures merged in the development process. About 71% of the respondents indicated that the partner culture (i.e., the practices and values of the partner organization) was a factor that influenced project success in project C. The partner culture influenced negatively the creation of shared goals in the project.

According to three respondents that were interviewed, the culture of one heavyweight partner
is characterized as very dominant. This hampered the achievement of a shared goal in project C because a large amount of effort went towards deliverables for this partner. In fact, two out of five operational members argued that the dominant culture of the partner resulted in additional requests that were not agreed upon initially. Consequently, the pressure on the internal project team increased because these requests hampered the execution other priorities in the project. Moreover, one operational respondent mentioned that “the dominant partner expected a lot of progress in the project which hampered the achievement of shared project goals”. 

Additionally, the different nature of involvement of partners created challenges in achieving shared objectives. Program management argued that the dominant partner wanted to be inspired by the project team by absorbing knowledge without contributing towards shared project objectives. Conversely, the other (heavyweight) partner examined the technological potential and provided direction to project for the achievement of a shared project objectives. In fact, the partner resident mentioned that “to achieve a shared goal, trust between collaboration parties is an essential element in long-term development projects”.

Project members perceived difficulties in realization of shared goals because of the different nature of involvement of partners. Especially, the dominant partner hampered the achievement of shared goals.

5.4.2.2. Factor 2: Knowledge sharing

Two heavyweight partners were involved project C. Both partners placed researchers at Holst Centre to contribute in the project team for the development of the technology. About 57% of the respondents indicated that knowledge sharing was a factor that influenced project success in project B. According to them, knowledge sharing affected the achievement of shared goals in the project team.

According to three respondents, knowledge exchange from the partner to Holst Centre was hampered because partners were not eager to provide application information due to the involvement of other (competing) partners in project C. This finding is also argued by Lhuillerya & Pfister (2009) who argued that organizations are anxious to disclose their knowledge to competitors in collaborative projects. Project members felt this as a hurdle in the creation of shared project goals. In fact, one partner resident argued that only specification knowledge was shared but application knowledge was not intended to be shared - “we have to keep our core competence to ourselves”. However, the resident argued that it was not his intention to refuse sharing application knowledge but from the partner management prospective this was not allowed due to competitive reasons. In addition, the interview with the partner resident revealed that partners are not only interested in the technology but also on the competitor’s objectives in the technology (i.e., the other heavyweight partner in project C). In fact, it was argued that the resident would like to know the specifications technological details of other partners for being able to grasp their application objective.

Additionally, three out of five operational respondents mentioned that information handling of the partner was sometimes perceived as a challenge for the partner due to the differences in expertise. This finding is also argued by Bogers (2011) as has challenge in collaborative projects. In fact, one operational respondent argued that one partner did not have the internal expertise in certain parts of
the technology, thus they had to rely on Holst Centre on the development in this particular part. This imbalance in expertise resulted in intensive discussions and clarifications on technical content, which made knowledge sharing more challenging. However, this situation was mediated by a partner resident who was part of the project team. The resident argued that it was easier to ask for clarifications directly in the project team and afterwards communicate it to the partner management. The resident is an intermediary between partner management and the project team, meaning that internal changes in prioritizations were also communicated directly by the resident to the project team.

Whereas competitors in the project made information sharing difficult for partners, retrieving competitive information was also considered as an objective for partners. Partner residents contribute to a smoother information sharing process by acting as an intermediary between partner management and the project team.

5.4.2.3. Factor 3: Project team functional diversity

Three internal expertise (discipline) groups in project C contributed to the development of the technology. About 43% of the respondents indicated that the functional diversity (i.e., different expertise of project members) was a factor that influenced project success in project C. Functional diversity negatively influenced the project team cohesion and the creation of shared goals initially.

According to two respondents that were interviewed, the inter-disciplinary collaboration between the discipline groups was only challenging in the start-up phase of the project. This was felt by project members as hampering the project cohesion because of intensive discussions on technical content. The interviews revealed that background expertise of the discipline groups played a role in these discussions. However, three respondents argued when the project evolved, discussions were necessary because they contributed in the alignment of internal priorities. Moreover these respondents argued that during the project, inter-disciplinary collaboration enforced project commitment due to the collective team effort towards project goals. Furthermore, technical discussions occurred also between suppliers and project members. In fact, one supplier argued that “discussions are not necessarily harmful for the collaboration but provoke even closer inter-disciplinary collaborations”. This finding is also noticed by the study of Carlile (2002) who argued that functional diversity have great potential but could as be a challenge.

Additionally, the involvement of residents increased the functional diversity in project C. The partner resident felt not completely recognized as project member initially because his contribution in the project team was marginal. However, this improved gradually when the resident made progress on technical content and communicated this in the project. In fact, the resident argued that after a few months he felt part of the internal project team. Two respondents argued that residents contributed to a clearer information exchange which enforced the creation of a shared goal in project C because partners show commitment by placing residents to participate.

Whereas inter-disciplinary collaborations resulted challenges initially, over time the project functional diversities enforced the project team commitment.
5.4.3. Conclusion project C

The three factors influenced project success by affecting the emergent states in the project team. In particular, organizational culture and knowledge sharing and also functional diversity were mentioned as factors by the respondents in project C.

The partner culture in project C referred to the dominant culture of one partner which was perceived as uncomfortable by project members. The technological success dimension showed that the technical outcomes were very satisfying during the life-time of the project. This implied that although there were internal challenges due the culture of one partner in hampering the achievement of shared goals, the project was successful. This finding suggested that the partner cultural challenges contributed to project success over time, even though this resulted in some internal challenges among project members during the project. Additionally, knowledge sharing referred to sharing know-how in project C. On the one hand, competition between partners in the project made information sharing difficult, influencing the shared development in the project. On the other hand, technical progress was booked due the contribution of partner residents in more effective information sharing process. Thus, although knowledge sharing was challenging, the partners guided the project by using residents to achieve technical results. Additionally, inter-disciplinary collaborations resulted in some challenges initially, while a large amount of technical results was booked during the project.

Interestingly enough innovation goal was not seen as an issue, even though there two significant partners involved. Overall the project goal seemed clear. Also there was no leadership issue and functional diversity was seen as contributing positively to the project after initial challenges.

Organizational culture, knowledge sharing and functional diversity influenced the internal project team dynamics (i.e., the emergent states) by creating multiple internal challenges. However, this finding was not necessarily negative for project success based on the technical achievements that were booked. In fact, it seemed that over time, inter-disciplinary work enforced internal collaborations resulting in technical progress. From a business prospective, project C was successful because at least half of the costs were covered (i.e., category two).
5.5. Summary of results

The investigation of the three project teams revealed that several factors influenced the project success in collaborative R&D projects. Figure 15 shows that six factors were found that influence collaborative project teams.

![Figure 15, Relative importance of factors found in projects A, B and C.](image)

The innovation goal hampered the creation of shared goals and decreased the team cohesion. The innovation goal was frequently mentioned as factor in project A and B but did not occur in project C. In project A shared innovation goals were not clear because there was no influence of partners, while in project B dedicated application goals of the heavyweight partner led to only partly shared innovation goals. Conversely, project C the innovation goals during the project seemed very clear, which explains why it was not mentioned by respondents.

Knowledge sharing affected the trustworthiness of the technology and the achievement of shared goals of the project team. This factor was mentioned in all three projects. Although there was no partner in project A, information was exchanged with potential partners. In project B, knowledge sharing was challenging due to the different natures of involvement of partners in the project (i.e., dedicated development vs. monitoring technology). In project C, knowledge sharing was difficult initially, but improved gradually due to the contribution of partner residents. Knowledge sharing is challenging due to the highly competitive environment in which project teams operate (Du Chatenier et al., 2009).

The organizational culture affected the achievement of shared innovation goals and project team cohesion. Organizational culture was frequent mentioned factor in projects B and C but did not occur in project A. The partner culture played a role in project B and C because the same dominant partner was involved both projects. In project A, no partner was involvement which explains why the partner culture was not mentioned as factor.

Project team functional diversity was a factor that influenced the trust and cohesion in project team and also could influence the achievement of shared innovation goals. This factor was mentioned by all internal project teams. All projects consist of a multi-disciplinary project team of three internal discipline groups. Challenges occurred in the collaboration among discipline groups due to diverse
backgrounds, expertise’s of project members.

Additionally, two factors found were only mentioned in one of the projects teams, namely leadership and partner organizational autonomy. Leadership issues were only mentioned in project A, which decreased the level of trust in achieving shared project goals within the project team, which in turn negatively affect the project team cohesion. Leadership issues were not mentioned in project B and C which implies that this was not a factor affecting the project teams. Organizational autonomy was only found in project B in which the partner autonomy influenced the trustworthiness of the technology. In project C residents contribute to better information exchange and mediated between the project team and partner management which could explain why partner autonomy was not of influence. Conversely, in project A no partner was involved which explains why partner autonomy was not noticed.

We can conclude that in project A, leadership issues and no clear shared goals seemed to enforce increased diversity challenges in the project team. Compared to other projects, less technological and business success was achieved in the last year of development, which can be explained by not having clear project goals and leadership issues. In project B, although the project goals were only partly shared, a heavyweight partner provided direction to the project to achieve technical results. Also no leadership issues were found. These findings seemed to contribute to project success based on the technical achievements that were booked and the partnership satisfaction. Finally, in project C, the innovation goal was not perceived as an issue which implied that innovation goals were clear, even though there two significant partners involved. Also there were no leadership issues and functional diversity was seen as contributing positively to the project after initial challenges. Project C performed better than projects A and B which could be explained by the clear and shared innovation goals and effective leadership to achieve these goals.

Out of the six factors found, four factors seem to be of major importance, namely innovation goal, organizational culture and leadership and project team functional diversity. Clear and shared innovation goals and effective leadership in the project, seemed to contribute positively to interdisciplinary collaborations and in turn, to project success. Effective leadership in this respect enforces a shared vision and shared innovation goals, as well as trust and cohesion in the project team. In fact, a study by Marks, Mathieu & Zaccaro (2001) argued that success is dependent on achieving a team objective, in which a shared vision among team members on objectives is essential as argued by Sethy (2000) and Revilla & Rodriguez (2011). Conversely, unclear (shared) innovation goals and leadership issues seemed to enforce increased diversity challenges in the project team and in turn, in less technical progress. Additionally, although dominant partner cultures were perceived as uncomfortable by project members, increased pressure by partners to achieve deliverables resulted in more technical progress but also enforced shared innovation goals to guide the project towards an application direction.
6. Discussion

6.1. Research objective

The research objective of this Master thesis was to identify the critical factors that influence project success in collaborative projects in an open-innovation environment. The literature suggested several factors that might influence the inter-firm R&D collaborations, as discussed in section 2.3.1. Based on the findings in literature it can be concluded that the current literature hardly discusses team level challenges within inter-firm collaborations, but is more focused on the organizational level of inter-firm collaborations. The academic goal of this Master Thesis is to contribute to the current scientific literature by providing new insights into the team mechanisms in inter-firm collaborations. The practical goal of this Master Thesis is to investigate collaborative R&D challenges in a business setting, and provide recommendations for current practice, for organizations in general and for Holst Centre specifically. Moreover, this study forms the base for an organizational-wide investigation on collaborative projects within Holst Centre in a subsequent study.

6.2. Research method

In order to investigate collaborative inter-firm projects, a multiple case study was conducted. The data collection was based on open-ended interviews with key project team members (e.g., project leader, project members and external stakeholders) in order to collect a wide range of information to create an understanding of the occurring team processes. The sample used for investigating the research question consists of 20 respondents from three currently employed collaborative R&D project teams performing in a high-tech environment at Holst Centre.

6.3. Conclusions

The main research question of this study focused on the overall relationship between input factors and project success. The main research question of this study is:

**How do input factors of collaborating partners influence inter-firm collaborative success in an open-innovation context?**

In answering this main research question it can be concluded that:

1. Clear and shared innovation goals in the project contribute positively to inter-disciplinary collaborations and in turn, to project success. Moreover, effective leadership is needed to have clear and shared innovation goals. The input of an innovation goal that is shared by all partners has a positive influence on the project team process because there is a clear innovation goal in which project members feel committed to achieve this goal. Even though functional diversity makes collaboration challenging initially, over time shared goals and effective leadership creating these shared innovation goals affect positively the diverse competences in the project team. Consequently, more technological and business success is achieved in the output phase. In contrast, unclear innovation goals and ineffective leadership
enforced increased diversity challenges in the project team and in turn, less technical progress. Thus, effective leadership - i.e. a project leader respected on technical expertise, and capable to create a shared vision and shared innovation goals, trust and cohesion in the project team - is essential for the achievement of shared innovation goals in the project because ineffective leadership will not result in shared innovation goals in the project.

2. An active partner provides direction and guidance to the project and hence to better project success. A dominant partner culture may be experienced as uncomfortable by internal project members because it may hamper the achievement of (partly) shared innovation goals in the project and the partner may force the project in potentially undesirable directions and goals. However, (dedicated) application directions initiated by partners guide the project towards clear requirements and provide direction to the project to achieve technical progress and business success. In fact, the increased pressure on the project team due to the partner dominance resulted in better team performance. Additionally, without partner involvement in projects in the research phase, it is difficult to guide the project to a higher level of application oriented development. Projects evolve towards the functioning and finishing phases due to contributions and (dedicated) specifications defined by active partners. Thus, actively involved partners are essential in providing a direction to the project leading to better project results, even if the partner culture is very dominant.

3. Partner residents contribute positively to the knowledge sharing process. Although competitive relationships between partners may make initial information exchange from partner to the project difficult, partner residents enhance effective information sharing between the partners and the project team. Partners guide the project by using residents which results in an effective collaboration and in turn, project success. Partner residents contribute to more effective information sharing by acting as an intermediary between partner management and the project team. This implies that residents also seem to mediate in strong partner autonomy, because they interact with the different layers of their own organization in which changing partner goals can be communicated directly to the resident, leading to fewer surprises in changing goals in the project team.

6.4. Research propositions

The input factors identified in this study are modified into constructs based on the conclusions in the previous section. The first conclusion suggests that shared innovation goals and effective leadership have a positive influence on an effective team process and moderate the relationship between functional project team diversity and effective internal team process. In addition, effective leadership is essential for the achievement shared innovation goals.

The second conclusion suggests that there is a moderating effect of one or more active partners on the relationship between innovation goal and effective internal team process. This implies that the more the actively involved partners the more clear the innovation requirements.

The final conclusion suggests that protective knowledge sharing and a strong organizational autonomy of partners have a negative influence on an effective team process. However, resident involvement can moderate this relationship. Additionally, based on initial discussions with project
leaders and program managers; shared goals, trust and cohesion seemed to be very important for an effective team process (chapter 3). Besides that, initial information obtained resulted in that technological, business and partnership success constitute the main dimensions of project success within Holst Centre’s open-innovation context.

Based on these findings, a causal model is proposed as shown in Figure 16 and presumed propositions based on this model are provided in Table 11. Important to note is that it seems plausible that there is also a direct effect of the input factors on project success. Whereas literature suggest direct relationships of team composition factors on project success, no empirical studies were found describing the relationship between consortium compositions factors and project success.

![Causal model of research findings](image)

**Figure 16, Causal model of research findings**

| Proposition 1.1. | Project success requires technological, business and partnership success. |
| Proposition 1.2. | An effective team process requires clear & shared project goals, trust and cohesion. |
| Proposition 1.3. | An effective internal team process contributes positively to project success. |
| Proposition 1.4. | Effective leadership contributes positively to an effective internal team process by creating project team cohesion, trust and clear & shared project goals. |
| Proposition 1.5. | Effective leadership contributes positively to shared innovation goals. |
| Proposition 1.6. | Shared innovation goals contribute positively to an effective internal team process. |
| Proposition 1.7. | The functional diversity in the project team contributes negatively to an effective internal team process initially. |
| Proposition 1.8. | Shared innovation goals and effective leadership reduce the negative relationship between functional diversity in the project team and effective internal team process which means that in that case, project success of diverse project teams is higher than of non-diverse project teams. |
| Proposition 1.9. | One or more active partners enforce the positive relationship of shared innovation goals on an effective internal team process. |
| Proposition 1.10. | Strong organizational autonomy & protective knowledge sharing have a negative relationship with an effective team process. |
| Proposition 1.11. | Resident involvement reduces the negative relationship between strong organizational autonomy & protective knowledge sharing and an effective internal team process. |

**Table 11, Research propositions**
6.5. Theoretical implications

In this study a conceptual model is developed based on fundamental teamwork models i.e., Input-Mediator-Output model of Mathieu et al. (2008) and Input-Mediator-Output-Input-model of Ilgen et al. (2005). The conceptual model is reduced to its essence in a research model based on the findings of this study in a collaborative inter-firm project team environment.

The first theoretical implication is that this study contributes to the existing team literature by providing insights on team processes and emergent states in a special team type namely, inter-firm project teams. The research model differs from earlier teamwork models in that multiple organizations (i.e., partners) provide input in the project team by consortium composition factors – which is a new concept proposed in this study. Multiple external stakeholders in the project make the presence of clear shared goals and trust for knowledge exchange particularly important in collaborative projects. In addition, according to the fundamental teamwork models, project outputs are used as project inputs for explaining future emergent states in the project team (Ilgen et al., 2005). However, because this study investigates inter-firm project teams, the feedback relationship from output to input phase only occurs on specific consortium composition factors e.g., a partner could take action for better knowledge sharing (input) to influence unsatisfactory outcomes positively.

Furthermore, the second theoretical implication is that current open-innovation literature hardly discusses team level challenges within inter-firm collaborations but is more focused on the organizational levels of inter-firm collaboration. Therefore, this study contributes to the gap in the current open-innovation literature by identifying consortium composition factors that influence collaborative R&D, focusing on operational levels rather than organizational levels of open-innovation. In particular the consortium input factor ‘organizational culture’ was suggested to have a possible influence in collaborative projects (Badir et al., 2009; Bogers, 2011; Tidd, et al., 2001) which is confirmed by the findings of this study.

The research model in this study provides a basis for future research on collaborative projects on operational levels of open-innovation, in that propositions are provided to investigate the causal relationships in Figure 16 more extensively in future research projects.

6.6. Practical implications

This section describes the practical implications deriving from this research project. The practical implications based on the findings of this study are intended to contribute to more effective collaborative projects in a high-tech R&D environment. The practical implications are described according to the three major conclusions found over three project teams investigated.

The first conclusion suggests that clear and shared innovation goals in the project contribute positively to inter-disciplinary collaborations and in turn, to project success. In which effective leadership is essential to have clear and shared innovation goals. This conclusion results the following practical implications:
There must be a clear innovation goal, which is shared in the overall project team:

- Active partner participation is required in an early stage of the development to guide the project towards an application direction with clear requirements as this will enforce a shared goal;
- Create a shared vision in the overall project team, by including discipline groups normally be involved in a later stage of the project;
- The topic of collaboration must be a shared goal that is achievable internally, and attracts sufficient future interest externally.

Effective leadership is essential in for creating a shared vision and goal in project team. Effective leadership consists out of the following competences:

- Recognized technical expertise in one domain to assure credibility in the project team;
- Capable to manage and coordinate different discipline groups and functions;
- Capable to create interactions and connections between discipline groups i.e. create trust and cohesion in the project team;
- Capable to create a shared vision and to exploit this vision in the overall project team;
- Create consensus in the overall project by creating a shared vision based on inputs of all involved parties;
- Create a shared vision supported by program management and in line with Holst Centre’s strategy.

The second conclusion suggests that the impact of an active partner contributes to project progress and hence to better project results, even if the partner culture is very dominant. This conclusion results the following practical implications:

Strive for actively involved partners because they guide the project towards an application direction and shared goals, even if the partner culture is dominant:

- Prepare the internal project team if a dominant partner culture is expected;
- Prepare the internal project team on how to deal with dominate partners i.e. develop a protocol & one single main point of contact:
  - Use weekly progress meeting to avoid direct interrupts of project members;
  - Discuss request of partners;
  - Discuss the internal feasibility of requests partner;
  - Achieve internal alignment on deadline proposition to meet partner requests;
  - Achieve internal alignment on the project priorities to achieve partner requests.
- When there is no actively involved partner:
  - Create more partner awareness of project results e.g. IP, scientific achievements, demonstrators;
  - Involve (potential) partners in new findings e.g. recent updates of results and project progress;
  - Encourage partners and prospects to visit Holst Centre to actually see the technology potential;
  - Encourage partners and prospects to contribute ideas;
  - Avoid major investments until (key) partner contributes in the project. Be flexible until partner involvement is secured.
The final conclusion suggests that partner residents contributed positively to the knowledge sharing process and the developments in the project. This conclusion results the following practical implications:

The contribution of partner residents resulted in more effective information sharing because it reduces the communication barriers from partners to the project team:
- Encourage partners to be actively involved in the project by placing residents.

To conclude, shared innovation goals in the overall project team and shared project vision supported by internal management are essential in inter-firm collaborative projects. This finding is also pointed out by a study of Revilla & Rodriguez (2011) who argue that a shared vision is essential, and all involved project members must be aware of the project vision in order to internalize and support them. Effective leadership in these project teams is necessary to achieve shared innovation goals and a shared vision that are support by all project members. This implies also that the project vision has to be aligned with program management and the overall strategy of Holst Centre and has to be aligned with involved partners. In addition, active involvement of partners – preferably with contributions of partner residents - is essential to guide the project towards an application direction with clear requirements as this will enforce a shared innovation goal. These findings suggest three overall practical implications most important in collaborative projects at Holst Centre.

- Shared project vision and innovation goal by project team and higher management at both Holst Centre and the partner side is a necessary perquisite for project success;
- Effective leadership is essential to create shared vision and innovation goals supported by all involved stakeholders in the project; effective leadership consists of technical expertise in one domain to be respected by technical peers and the competence to create consensus on a shared project vision in the project between project team members and management of all partners, while being sensitive to cultural differences.
- Active partner involvement is a must, preferable with the contribution of residents.

6.7. Limitations

This exploratory study investigated three inter-firm project teams in-depth and developed a research model and causal model to provide directions for future research. Although three project teams is a limited number to draw extensive conclusions upon, the total amount of 20 respondents is excellent for a case-study. Moreover, this study was intended to be exploratory for investigating the relatively unknown challenges in collaborative projects. Besides that, the different levels of respondents in the projects i.e., operational members, managerial members and respondents of external parties contributed to the internal validity of this study. Unfortunately, only one external partner was interviewed per project because other partners involved were not willing to contribute to this study even after several requests by different sources, this resulted in less validation on external responses. Nevertheless, in collecting data about project success dimensions, the fact that a different source and measurement instrument was used to measure project success reduces problems of common method
bias in the analysis. Additionally, face-to-face interviews may have possibly resulted in problem focused (negative) responses. Respondents tended to argue more easily on negative situations (i.e., problem focused) than positive (i.e., success focused) situations. Some problem focused interview questions in this study could have provoked negative responses from respondents to identify the critical factors in collaborative projects, even though the intention was to elicit both negative and positive responses.

Furthermore, the identified input factor ‘organizational culture’ was based on one partner involved in two projects investigated. This could bias the result that organizational culture is of influence in projects because this finding depends on only one partner. In addition, the scope of this study is limited because the investigation is conducted in one organization (i.e., Holst Centre) and is therefore dependent on this specific organizational context which reduces the external validity. Besides that, the findings in this study cannot be generalized internally in the organization due to sample size of only three project teams. However, three project teams consisting of diverse technologies, project phases and project goals are investigated in-depth to explore the occurring team dynamics and the challenging factors in collaborative projects. The intensive investigation of three diverse project teams and multiple external and internal respondents contributed to the quality of this exploratory study. Moreover, the findings of this study provide a solid base for future research projects, therefore research recommendations are provided in the next section.

6.8. Recommendations for future research

This explorative study has gained insights in the critical factors that influence project success in collaborative inter-firm project teams. The findings show that clear and shared innovation goals in the project contributed positively to inter-disciplinary collaborations and in turn, to project success. In which effective leadership was essential to create clear and shared innovation goals, supported by all involved stakeholders in the project. In addition, the impact of an active partner – preferable with the participation of partner residents contributed to project progress and hence to better project results.

The major recommendation for future research is to pursue a quantitative study to generalize the findings of this study and to validate the research model and research propositions. Although the findings among three teams investigated are not generalizable, the outcome of this research provides a solid basis for a company-wide investigation of Holst Centre’s project teams, and also for inter-firm project teams in other organizations. The research model in Figure 6 provides a base for future research on collaborative projects on operational (project team) levels in an open-innovation environment. Besides that, several research propositions are provided (section 6.4.) to investigate the relationships in collaborative projects more extensively. It is advisable to use a sample size suitable for quantitative research and statistical analysis. For example, an electronic survey based on the input factors found in this study to confirm or reject the research propositions. Again, collect information of different hierarchical levels of respondents for validation of the findings. Besides that, it would be interesting to compare the responses on different hierarchical levels to investigate the diverse outlooks of project members on collaborative projects, which might result in specific practical recommendations. In addition, include new insights from open-innovation and team literature that might be relevant in this
The low response rate of external partners is a problem that was perceived in this study. Therefore, it is recommended to select more project teams in which several partners are involved to increase the response rate of external organizations. In addition, it would be recommended to conduct an investigation among inter-firm project teams in different organizations for increasing the response rate. Furthermore, it is recommended to reduce the possible negative responses in future research projects, by including questions that provoke a balance between positive as well as negative answers. It is advisable to set up a questionnaire that focuses on problems as well as successes in collaborative projects. This might result in more data about factors that were not mentioned by respondents in this study (i.e., factors with a 0% score in Figure 15), which were assumed to be positive or not relevant in projects teams in this study. Finally, it would be interesting to investigate if the identified factors in this study are perceived as equally important among respondents. In sum, the recommendations for future research are as follows:

- Pursue a quantitative study (e.g., electronic survey) to generalize the findings of this study and to validate the research model and research propositions;
- Increase validity of quantitative study by investigating multiple inter-firm project teams within Holst Centre and among other organizations;
- Reduce possible negative responses in future research by focusing on problems as well as successes in collaborative projects;
- Investigate if the identified factors in this study are seen as most important among respondents.
References


**Other references:**

Holst Centre Executive Report (2010)
### Appendix 1: List of keyword definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active partner</td>
<td>A partner actively involved in the project</td>
</tr>
<tr>
<td>Cohesion</td>
<td>The commitment of team members to each other to achieve the team objectives</td>
</tr>
<tr>
<td>Consortium composition factors</td>
<td>Opportunities given and conditions set by the involved organizations in the project</td>
</tr>
<tr>
<td>Effective leadership</td>
<td>Demands that the project leader is respected on technical expertise, but also creates a shared vision and innovation goal among all parties involved in the project</td>
</tr>
<tr>
<td>Heavyweight partner</td>
<td>A partner involved in several technological programs within Holst Centre</td>
</tr>
<tr>
<td>Dominant partner</td>
<td>An highly influential and active partner in the project</td>
</tr>
<tr>
<td>Inter-firm collaboration projects</td>
<td>Two or more independent organizations interacting adaptively, interdependently and dynamically towards a common and valued goal.</td>
</tr>
<tr>
<td>Innovation goal</td>
<td>The project direction and objectives shared with partners involved in the project.</td>
</tr>
<tr>
<td>Knowledge sharing</td>
<td>The degree of sharing information (e.g., application know-how) from partners to the project team.</td>
</tr>
<tr>
<td>Leadership</td>
<td>The way project teams are managed and coordinated.</td>
</tr>
<tr>
<td>Organizational autonomy</td>
<td>Top-down power influences of partner management in the project teams.</td>
</tr>
<tr>
<td>Organizational culture</td>
<td>The practices and values of the partner organization.</td>
</tr>
<tr>
<td>Project team functional diversity</td>
<td>The diverse expertise of project members in the internal project team.</td>
</tr>
<tr>
<td>Resident</td>
<td>Partner employee stationed in the internal project team at Holst Centre.</td>
</tr>
<tr>
<td>Team composition factors</td>
<td>Opportunities given and conditions set in the internal project team by Holst Centre.</td>
</tr>
<tr>
<td>Team emergent states</td>
<td>Motivational, cognitive and affective states of teams</td>
</tr>
<tr>
<td>Trust</td>
<td>The confidence and belief in other team members.</td>
</tr>
</tbody>
</table>
Appendix 2: Interview

Introduction

Research Objectives
This research objective is to determine the critical elements that influence project success in collaborative R&D projects within Holst Centre. Increased insight into these elements in the collaborative R&D projects may prove helpful in establishing more effective and successful future collaborations.

Questionnaire information
This interview is conducted face to face and will contain open-ended questions. The duration of the interview will be approximately 1 Hour. The information collected is confidential and will be reported as anonymously.

Section 1: Demographics

-- I would like to start with some general questions about yourself and some information about your current job --

1.1. Interview Date: ____________ 2012
1.2. Interview location: Holst Centre Eindhoven | Imec Leuven | Teleconference | Other, ____________
1.3. Respondent name: ____________
1.4. Nationality: ____________ Work experience: _________ years
1.5. Respondent function: Project Manager | Program Manager | Internal Member | External Member | Resident | Supplier | Other, ____________
1.6. Could you describe your current function within the Holst Centre?

Section 2: Project team information

-- I would like to proceed with some questions about your involvement in the project team and your impression on past or current progress of the project --

2.1. Member of project: e-Nose | UWB-streaming | BAN-radio | Other, ____________
2.2. Involved in project since: less than 1 year | 1-2 years | 2-3 years | more than 3 years
2.3. Can you tell me a something about the project?
2.3.1. Can you describe the main project objectives?

2.3.2. Can you explain what the nature of your involvement is/was in this project?

2.3.3. How would you describe the project progress and achievements?

Section 3: Project deliverables

-- The next questions will be about the project deliverables, especially focused at the vision of different project groups on these project deliverables --

3.1. To what extend do you believe that the objectives of Holst Centre and partners are in line with one another?

3.1.1. If not, did this harm the project?

Section 4: Project relationships

-- The questions in this section will be about the project relationships between different discipline groups and the relationships with external partners. I will first start with some questions about the information exchange within the project --

4.1. Can you explain the information exchange in the project – internal and external?

4.1.1 What factors can you identify that might influence the information exchange in a positive or negative way?

4.2. To what extend do you believe that project members are/were committed to one another to achieve project objectives?

4.2.1. What factors can you identify that might influence project cohesion in a positive or negative way?

4.3. To what extend do you believe that project team closeness* is important for project success?

*cohesion, sense of belonging to the project team.

-- The next questions will be about the impression of trust within the project team --

4.4. To what extend do you believe that people trust one another working towards the same objectives?
4.5. To what extent do you believe that mutual trust is important for project success?

4.6. How do you feel about sharing information with external partners?

   4.6.1. What factors can you identify that might influence the knowledge sharing in a positive or negative way?

4.7. Do you think that is it sometimes better not to share certain information?

4.8. To what extent do you think that team empowerment plays a role in achieving project objectives?

4.9. To what extend does the project team believe in its ability to achieve project objectives?

-- Looking at the bigger picture of the collaborations at Holst Centre --

4.10. To what extend do you think that there is/was a shared vision on the innovation roadmap*?

   4.10.1. What factors can you identify that might influence a shared vision in a positive or negative way?

*Opportunities, challenges, trends.

<table>
<thead>
<tr>
<th>Internal respondents only:</th>
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<tbody>
<tr>
<td>4.11. To what extend do you believe that the input from external partners is/was valuable for the development process?</td>
</tr>
<tr>
<td>4.11.1. Could you describe what kind of partner expertise is/was essential for the project?</td>
</tr>
<tr>
<td>4.11.2. How would you describe the relationship with partner(s)?</td>
</tr>
</tbody>
</table>

4.12. Do you think that there is/was a shared understanding of the strategic priorities in this project?

4.13. To what extend do you believe that consensus about strategic priorities is important for project success?

4.14. To what extend do you believe that a shared understanding of the project process is important for project success?

**Section 5: Finalization**

5.1. Are there any disagreements that occurred during the project?

   5.1.1. Can you give me examples?
5.1.2. How were they solved?

5.2. To what extend do you think that the resources around Holst Centre (e.g. suppliers, manufacturing organizations and research institutes) contribute to the project?

5.3. What do you think is most important for achieving project success?