8. Conclusions

The author of this book used a sociological perspective to analyze the management of collaborative innovation that draw on different sources of knowledge within and outside the development firm (cf. Chesbrough, 2003, 2006a; Tell, 2017). Based on six empirical cases of technology development in the wind energy industry, the author discussed the extent to which the innovation partners were able to establish a collaborative innovation praxis based on shared working standards. It was expected that such an innovation praxis would normatively bind representatives of different organizations despite their different interests and cognitions.

The author's overall aim was to identify the regulative and normative elements that explain why innovation projects do not achieve their intended outcomes (cf. Scott, 2008). In particular, the author has analysed how the social process of establishing a collaborative innovation praxis differs across innovation contexts. It was found that innovation can take place in three different context. Incremental innovation (within a technology life cycle) rather happen in organized and stable but changing fields; radical innovation (beyond the present technology cycle) is most likely to occur in organized and unstable fields that are open to transformation; while unorganized or emerging fields provide opportunities for new actor constellations and technologies (cf. Fligstein & McAdam, 2011, p. 11; Foucart & Li, 2021). The associated innovation praxis is described below.

The findings of the author of this book advance our understanding of the management of collaborative innovation, a topic of intense debate among innovation scholars and practitioners alike. The study provides empirical evidence that the management of collaborative innovation must be understood as a social process of establishing shared standards that normatively integrate professionals from all relevant organizations. It will be argued that such a collaborative innovation praxis is particularly important for those innovation projects that aim to create new knowledge beyond established technological architectures.

This chapter provides a brief overview of this argument. It also summarizes the empirical findings and draws conclusions about the institutional barriers to collaborative innovation.

8.1 The author's main argument

The introductory chapter argued that complex innovation projects can be called collaborative when professionals from formally independent organizations work together to develop a new technology in a particular sector. An innovation project is realized when a new technology is commercialized in markets or applied in a firm's production processes. Complex technologies such as wind turbines are particularly suitable for analyzing collaborative forms of firm innovation processes. Wind turbines are technological architectures composed of different subsystems and components (Huenteler et al., 2016a, b). Due to the associated technological interdependencies between the components, which touch on different bodies of science-based technical knowledge, such as information technology, sensor technology or new materials, but also due to extensive regulatory requirements as well as customer demands, the introduction of complex wind energy technologies usually relies on the collaboration of experts from different organizations, such as system developers, supplier companies, research institutes, certification bodies, public authorities or technology users.

The author of this book assumes that because the member organizations specialize in different areas of expertise, collaborative innovation is necessarily confronted with different cognitive frames, but also potentially conflicting interests of the professionals involved as representatives of different organizations in the field. Therefore, the author of this book argues that professionals involved in collaborative innovation need to define common meanings, interpretations, and norms. The resulting system of inter-organizational shared working standards normatively integrates the different professionals, thereby facilitating technical problem solving and compromise in spite of potentially conflicting self-interests.

It has been proposed that each innovation project engages in social processes of establishing working standards, such as a shared concept of time (e.g., milestones), exclusive communication channels between project managers (e.g., single points of contact), or shared simulation-based engineering routines between relevant development partners such as customers, system developers, component suppliers, or certifiers. Such shared working standards, created in the process of technology development, normatively bind the innovation partners together and 'bridge' knowledge boundaries between them. In fact, the praxis of reflexively defining shared working standards is argued to be crucial for the management of collaborative innovation.

From this perspective, the management of collaborative innovation is not only about efficiency and new technologies, but also about a largely social process of establishing shared working standards (cf. Jackwerth, 2017;

Lawrence, 2010; Lawrence & Suddaby, 2006). This collective effort to norm the distributed work creates the collective agility needed to rapidly combine technical knowledge distributed across organizations (cf. Zheng et al., 2010). Shared working standards provide a common cognitive framework that informs stakeholders about the 'rules of the game' in an innovation project (North, 1990) as well as the consequences of deviating from the jointly established 'ways of doing things' (Elster, 2007). The social process of collaboratively norming distributed technology development thus plays a key role in understanding the outcome of innovation projects.

8.2 Advancing innovation management research

This book contributes to the debate on the management of collaborative (or open) innovation. As shown in chapter 2, there is an intense debate in the management literature on the management of innovation projects. In particular, the open innovation approach postulates that inter-firm collaboration is positively associated with better products, services and processes (Chesbrough, 2003, 2006b). A literature review of empirical studies on open innovation in Chapter 2 identified three factors that influence the outcome of open innovation projects: the type of collaboration (horizontal/vertical), the specificity of knowledge (broad/specific), and appropriability regimes (formal/informal knowledge protection rules) or the rationality of management decisions such as 'strategic openness'. However, the open innovation approach has also been criticized for relying only on success stories of technology development to show how openness leads to innovation.

The lack of a theory of open innovation is the reason why management scholars cannot explain the outcomes of collaborative innovation. In fact, tracing the social process of innovation is not the primary research interest of open innovation scholars, as (Bogers & West, 2012, p. 65) point out: "*The core research questions in open innovation research are how and when firms can commercialize the innovations of others and commercialize their valuable innovations through others.*" Because of this theoretical blind spot of open innovation, which is fixated on the business goal of commercialization of technical knowledge, the author of this book has taken a sociological perspective to uncover the institutional conditions that hinder the potential of collaborative innovation.

As discussed in Chapter 2, a relatively new strand in the management literature, the knowledge integration approach, takes a more theory-oriented view of the challenges of managing collaborative forms of learning and innovation. Founded by Robert M. Grant, recent contributions and empirical studies from a knowledge integration perspective illustrate that in technology-based industries organized around complex technologies, such as energy production, automotive manufacturing, heavy electrical equipment, telecommunications, or tooling, it is typical for innovation projects to integrate specialized knowledge from different professions, organizations, and sectors (Berggren et al., 2011a). However, the literature on knowledge integration also shows that in such industries, technologies are typically introduced through hierarchical, pyramidal networks dominated by large incumbents at the top. These empirical findings show that managing collaboration requires understanding how powerful actors define the 'rules of the game' or 'how things are done' in a given industry (cf. Edquist, 2005; Elster, 2007; North, 1990, p. 427).

The author of this book adopted the insight from the knowledge integration literature that network structures influence the outcome of innovation projects. Empirical studies have shown that within the boundaries of established technology-based industries, technologies are typically introduced through hierarchical innovation networks. Therefore, social interactions in innovation projects within a single industry, as well as power asymmetries between incumbents and challengers in the field, are important to study from a knowledge integration perspective (cf. Fligstein & McAdam, 2011, 2012). By rejecting the economists' assumption that sectors are homogeneous social systems whose boundaries are defined abstractly by "*broad and related product groups, (...) similar existing or emerging demands, needs and uses, (...) common knowledge bases*" (Malerba & Adams, 2014, p. 188), the knowledge integration approach thus looks specifically at different forms of collaborative combination of knowledge that may could come from very different sectors.

In addition to looking at practices of knowledge integration across organizations, management scholars also argue that cognitive structures can hinder collaborative innovations. In particular, knowledge boundaries are understood as institutionalized barriers to collaborative innovation (Berggren et al., 2017; Orlikowski & Gash, 1994; Tell, 2017). This literature assumes that as long as innovation partners share similar epistemic backgrounds (e.g., professional education, individual training, tacit knowledge, personal experiences, theories, language, identities, or value systems), they form what sociologists call epistemic communities (Håkanson, 2010). Because of their fairly homogeneous cognitive frameworks, members of an epistemic community can easily exchange information even over large geographic distances. Management scholars assume that at least a minimal overlap of knowledge between innovation partners is necessary to be able to collaborate, but also to maintain efficient work processes.

However, as this book has shown, collaborative innovations typically rely on collaboration between organizations with different specializations. As a result, cognitive frameworks are likely to be highly heterogeneous, and knowledge overlap is difficult to achieve. Innovation projects run the risk of suffering too much from unintended outcomes if cognitive differences or knowledge boundaries between all relevant innovation partners are not 'bridged' by routines, rules or standards of knowledge integration that normatively integrate the professionals involved. However, the social praxis that 'bridges' such knowledge boundaries have remained an open question.

To fill this research gap, the author of this book approaches the management of collaborative innovation as a social praxis. Its social 'production' can be analyzed by looking at the practices of collaboratively combining expertise across professional, organizational and sectoral boundaries (*practices of knowledge integration*), which are influenced by more or less institutionalized rules, norms or standards (*such as examples, models, levels, norms of technology development*) concerning the design, construction and testing of a new technology (cf. Elster, 2011). This – in theory – creates a praxis of collaborative innovation.

Supported by the empirical analysis, the author of this book considers the praxis of establishing shared rules and norms as the key for the management of collaborative innovation (cf. Lawrence, 2010; Lawrence & Suddaby, 2006). Innovation projects aimed at the development of new technologies are rarely a harmonious endeavor, but usually involve different cognitive frameworks and self-interests that compete with each other. The praxis of collaborative innovation thus refers to the constant (re)creation of shared rules and norms that provide professionals with a common cognitive frame that informs them about the 'rules of the game' (e.g., design rules) that apply in a particular innovation project, as well as the consequences of deviating from the established standards of technology development (e.g., warranty claims). Thus, the praxis of establishing shared working standards exerts the normative power necessary to bind innovation partners together despite their different cognitions and interests.

All in all, from a sociological perspective, the management of collaborative innovation is based on a praxis of establishing a shared standards of collaboratively combining knowledge and solving technical problems. Working standards then contain typified ways of solving problems that, because they are routinized, make collaboration predictable, relieve collaboration partners of the need to calculate each step, and provide recipes (recipe knowledge) for dealing with technical problems (cf. Berger & Luckmann, 2009, p. 58).

The author's main research objective was to empirically evaluate this key argument. For this purpose, it was theorized that collaborative innovation can be realized on the basis of three strategies: 1) An innovation project may incrementally improve an existing technology architecture, 2) it may aim to introduce a radically new technology by reconfiguring an architecture or creating a new one, or 3) it may operate in emerging technology fields where neither technical standards nor innovation networks are yet established and thus new collaborations need to be created. Therefore, the following three propositions guided the empirical evaluation:

> *Proposition 1 (P1): The praxis of innovation is mainly shaped by the monitoring of technical standards and the sanctioning of nonconformity when innovation projects are initiated in organized and stable fields.*

> *Proposition 2 (P2): When a radically new technology is being developed, the praxis of innovation is likely to be shaped by newly created procedures and methods for solving collaborative problems.*

> *Proposition 3 (P3): When an innovation praxis has to establish itself in an emerging sector, it is likely to adapt technical standards from adjacent fields.*

In P1, the innovation praxis of coordinating the ongoing (re)creation of shared rules and norms is largely limited to monitoring established technical standards and sanctioning nonconformity. In P2, the innovation praxis refers to the creation of new shared work standards, while in P3 the innovation praxis is directed towards finding and adapting technical solutions from other fields. These strategies were evaluated in chapters 5 to 7 on the basis of empirical findings from six innovation projects in the wind energy industry. These results are summarized below.

8.3 Summarizing the empirical findings

Based on the empirical evaluation of six innovation projects, this section discusses the extent to which shared rules and norms influence the outcome of firms' innovation processes. To present the results, the findings are first summarized separately for each type of innovation, namely incremental innovation, radical innovation, and emerging technologies. In particular, for each type of innovation, the findings are presented with respect to the underlying practices of knowledge integration, a key challenge in managing collaborative innovation.

Table 20 provides an overview of the empirical results. The author of this book found three innovation praxis. One referred to the coercive imposition of technical standards found in the incremental innovation examples. However, enforced imposition also runs the risk of reducing innovative projects to mere contract development rather than innovation. The second praxis is the reliance on personal trust in the cases of radical innovation. A third innovation praxis, found in the examples of emerging technologies, is individual technical imagination or collaborative trial-and-error learning. The latter two mechanisms are less effective in realizing collaborative innovations, which provides empirical support for the proposition that the creation of new technologies – especially those, which deviate from established technology architectures – depend on an inter-organizationally shared innovation praxis, as will be discussed below.

Table 21: Summary of the findings

Innovation type	**Integrating knowledge**	**Realizing technology development**	**The innovation praxis**	**Institutional barriers**
Incremental innovation	Based on centrally controlled enginee-ring and manufacturing procedures	Using various contracts to predefine innovation projects	Coercive power (based on contracts, technical standards, homogeneous knowledge)	Coercive rules reduce innovation projects to mere order development
Radical innovation	Based on a newly established network in case C, and a boundary spanner in case D	Establishing a praxis of material testing (case C) or using a technical specification sheet to gain some control (case D)	Relying on personal trust (to gain some control over the innovation process)	Relevant development partners were not sufficiently integrated
Emerging technologies	Based on individual abilities (case E) or unique offshore engineering competences (case F)	Relying on technical inventions (case E) or creatively combining technical knowledge (case F)	Technical imagination vs. trial-and-error learning (case E), collaborative engineering with scientists (case F)	No stable position as a trusted system supplier establis-hed in the field

8.3.1 Using coercive power to impose technical standards

The first two cases compared two component suppliers working with a large European wind turbine manufacturer (WTM) to design and build a new component for wind turbines. In Case A, a medium-sized component supplier, an established specialist and market leader in large components, worked with a WTM. In case B, another medium-sized component supplier, formerly specialized in the rail vehicle industry, collaborated with another large WTM. In both cases, the collaboration took the form of a hierarchical innovation network, with the WTM at the top controlling technology development. Horizontal collaboration, which is typical for the development of new technologies, was hardly observed.

The knowledge integration process took different directions in the two cases. In case A, the WTM imposed its technical expectations and largely predefined the entire innovation project based on detailed technical specifications. The component supplier relied on highly standardized engineering and manufacturing processes, mainly to combine different types of technical standards (such as industry standards, customer expectations, or internal guidelines) to develop a prototype. In this case, the practices of knowledge integration were already well established among the innovation partners.

In Case B, the component supplier was a newcomer to the wind energy industry and therefore an outsider to established supply networks. The supplier initiated an innovation project and, together with a WTM, developed a new component for stopping rotors that was radically new compared to established component technologies in the field. In this case, knowledge integration and collaborative innovation were observed only at the beginning of the innovation process, when the supplier company collaborated with an applied research institute to develop a first prototype. Later, after the product was introduced to the wind energy industry, knowledge integration took place mainly within the organizational boundaries of the supplier firm, which created additional product versions to attract new customers. Interestingly, the innovation partnership between the supplier and its main customer, WTM, quickly turned into a mere contract development. Thus, the partnership became a hierarchical market relationship that was strictly controlled by the WTM and left little room for collaborative innovation.

In addition to the knowledge integration processes, this study also analyzed how the two innovation projects were organized. In Chapter 3, it was suggested that incremental innovation projects are organized through practices of monitoring technical standards and sanctioning nonconformity (P1). The innovation project in Case A was organized in three ways: First, the customer largely imposed its technical expectations based on various contractual agreements (e.g., framework contracts, development contracts, and non-disclosure agreements). Second, it could also be shown that the customer centrally controlled the external technology development. Both partner organizations were structurally coupled based on a common understanding of time (e.g., milestones), direct communication channels between project managers (single points of contact; SPOCs), and a homogeneous knowledge base. Interestingly, centralized control, based on well-defined process standards, quality standards, and transparency standards, also included personal inspections. These findings hardly support P1, which assumes that in incremental innovation projects collaboration tends to be horizontal and even the most powerful actor cannot rely on coercive power to realize a project due to functional interdependencies and knowledge complementarities. In this case of an incremental innovation project, however, coercion based on contracts and the imposition of technical standards emerged as the dominant mechanism of collaborative innovation. Rather than establishing a shared praxis of collaborative innovation, coercive rules reduced the project work to mere contract development.

Similarly, Case B also showed few signs and efforts of collaborative innovation. On the contrary, although the component supplier collaborated with a large WTM to introduce a radically new product, this collaborative innovation partnership quickly turned into a simple market transaction. The customer, i.e. the WTM, centrally controlled the supply relationship by imposing product prices and interface data on the component supplier. Thus, in contrast to P1, centralized power-based control emerged as the dominant mechanism of technology development. Mutual dependencies and knowledge complementarities typical of collaborative innovation were not found. In this case, technical standards (e.g., technical interfaces) were used instrumentally to minimize knowledge integration and to control the entire component supply network. Similar to the first case of incremental innovation, coercive rules reduced the innovation project to a mere order development.

Overall, in both projects, coercive power was the dominant strategy. In case A, however, this praxis could be linked to a loss of innovation capability of the organizations. The established rules can be interpreted as an institutional barrier to collaborative innovation. The results showed that the imposition of technical standards limited the creativity of component suppliers. In addition, it was shown that technological interdependencies between the major components of a wind turbine (such as the rotor, gearbox and generator) can be optimized based on closer collaboration with all relevant component suppliers. However, in this empirical case, WTM actively prohibited such horizontal information sharing. Therefore, the author of this book concludes that when coercive rules of technology development prevent wind turbine component suppliers from collaborating with others to optimize the technological architecture of the wind turbine, it leads to rigidity and reduces the innovative capacity of an entire innovation network.

Case B showed a similar picture. Because WTM, the supplier's main customer, explicitly prohibited further major technical improvements, the component supplier could not expand its product range and engage in additional innovation projects with other large customers. The lack of such collaborative innovation partnerships was the reason why the supplier remained trapped in a market niche.

The strategy of coercive power that systematically inhibits collaborative innovations and socially reduces the innovation projects into a pure order development relationship is illustrated in Table 21 below.

Table 22: The praxis of innovation

Cases	Strategies	Innovation praxis
A & B	Coercive imposition of technical standards	Reduced innovation capability of the collective of organizations
C & D	Relying on personal trust	The social closure of the innovation process is constantly being undermined
E & F	Individual imagination of technical solutions (case E) Trial-and-error learning (competitor firm in case E) Collaborative engineering with scientists (case F)	The innovator lacks legitimacy in the eyes of the partners who are crucial for the development and the deployment.

8.3.2 Relying on personal trust to gain some control

The third and fourth cases presented two radical innovation projects. In Case C, a German rotor blade factory and subsidiary of a large European WTM introduced a robotic rotor blade coating line. Coating rotor blades in an assembly line-like fashion was radically new to the wind energy industry. In Case D, a small German start-up company pursued its radical idea of a new support structure for wind turbines using wood as a construction material instead of steel or concrete.

The practices of knowledge integration were organized differently than in cases A and B. Both companies – the rotor blade factory and the start-up – initiated the innovation process, set up a project organization, and collaborated with partners specialized in previously unknown areas of expertise. For example, the factory collaborated with process automation experts specializing in automotive manufacturing, while the start-up collaborated with various experts specializing in wood engineering. However, these collaborations were less horizontal than expected in a context of radical innovation.

In Case C, a general contractor located several hundred kilometers from the factory designed, built, and tested the new technology. Other key project partners had little influence on the innovation process. For example, the factory and its main customer could only rely on a local, trusted technology specialist and boundary spanner to specify the project idea, using the technical specification sheet as a boundary object to control at least part of the external technology development process. However, a coherent collaborative innovation praxis between the three main actors – the client, the general contractor and the technology specialist – was hardly observed.

In Case D, a start-up company successfully coordinated an innovation network and collaborated with specialists from different fields of expertise to design the first prototype of a 'wooden wind turbine'. In this case, it was interesting to observe that once the prototype was developed, the public authorities responsible for approving the new design took control of the innovation process. In order to prove that the new design met public safety expectations, the approval authority imposed additional technical experiments on the project. As a result, the start-up company expanded its innovation network to include more wood engineering experts from university departments and material testing institutes. In fact, the start-up company established a praxis of collaborative testing of the 'wooden wind turbine' and developed new technical solutions with scientists to improve the prototype. By formulating additional technical requirements, the approval authority also became a relevant development partner, but was integrated too late in the entrepreneurial innovation process of the start-up company.

In the two cases of a robot-based rotor blade coating system and the 'wooden wind turbine', technology development was less horizontal than expected on the basis of proposition 2 outlined in chapter 3. A praxis of collaborative innovation was observed only for specific tasks or stages of the innovation process, such as material testing and science-based experimentation in case D, or the specification of customers' technical requirements in case C. Furthermore, in both cases not all relevant development partners were sufficiently integrated into the innovation processes, which might have significantly caused the unintended outcomes (project delays, quality defects). Based on these findings, the original assumption that radical innovation projects are organized on the basis of newly created procedures and methods of collaborative problem solving (P2) can only be partially supported.

In case C, P2 must be partially refuted, because a collaborative innovation praxis was found only in the stage of technical conception, when the rotor blade factory worked together with various external specialists to negotiate technical solutions and elaborate a technical specification sheet. At this stage, an external technology specialist and trusted partner of the factory management played the role of facilitator and boundary spanner. However, the later stages of technology development remained under the control of the general contractor and system supplier: a common interest in collaborative innovation and "*knowledge transfer*", as one interviewee put it, was not observed. Instead, the project work was characterized by large geographical distances, mistrust, and tactics of keeping proprietary knowledge secret.

In this sense, Case C suggests that a shared praxis of collaborative innovation is necessary for the success of radical innovation. In the case of the development of a robotics-based rotor blade coating system, the lack of a shared innovation praxis led to 'blind spots' in technology development that caused significant quality defects that could only be resolved several months behind the project schedule. Relying on personal trust, on the other hand, proved to be an inferior strategy for managing radical innovation projects. Relying on personal trust implies that a project team relies on individual expertise instead of defining common 'rules' or 'ways' of developing a new technology. Only such an established innovation praxis would be able to socially integrate all relevant development partners.

Case D shows a similar picture. A collaborative innovation praxis was found during the approval process. In order to get the prototype of a 'wooden wind turbine' approved for construction, the start-up company collaborated with experts from material testing and scientific institutes to prove the safety of its design. However, it was too late to involve the regulatory authorities in the innovation process. Due to the radical nature of using wood as a construction material for wind turbines, the constant interpretation of standards kept the innovation process open and delayed the approval decision. Thus, in contrast to P2, the approval authority centrally dominated this later stage of the innovation process. In the end, the start-up relied on the personal trust that the public approval authority placed in a renowned wood engineering expert to socially close the innovation process.

In conclusion, the example of the 'wooden wind turbine' supports the conclusion that in radical innovation projects, the process of establishing a collaborative innovation praxis and the social integration of all relevant development partners – here: approval and material testing authorities – can create the normative power to socially close an innovation process and to bridge incongruent technological frames by defining common working standards. However, the example of Case D also shows that if the approval authorities are not integrated into the innovation process at an early stage, time-consuming experiments and norm interpretations are likely to delay the realization of the project. In our case, the project was completed ten months behind schedule. Another finding of Case D is that because radical innovation projects are uncertain, long-term, and expensive, simply relying on reputable experts, individual assessments, tacit knowledge, or idiosyncratic decisions to develop a new technology is a risky strategy, especially for small firms that need to commercialize new technologies quickly and lack the resources to develop further technologies if a previous initiative has failed.

8.3.3 Individual imagination vs. trial-and-error learning

The fifth and sixth cases illustrate how two engineering service providers attempted to introduce a new technology into an emerging field of technology development in the offshore wind energy sector. The empirical findings showed how a new technology field emerged in the German offshore wind energy industry as a result of new environmental regulations imposed by a public licensing authority to protect marine fauna from noise emissions caused by installation work at sea. The findings support the proposition that "*in the wake of a significant new piece of legislation, we are likely to see organizations or groups move in to take advantage of the new opportunities for strategic action it creates*", thereby creating a new field, as Fligstein & McAdam (2011, p. 13) assert.

For new fields, it was assumed in Chapter 3 that neither technical standards nor innovation networks are established, so that innovation projects have to adapt technical solutions from adjacent fields (P3). This is reflected in the two cases studied, where technology firms that previously served customers in other industries perceived the new field as a business opportunity to gain new customers. Thus, both firms were newcomers to the offshore wind industry. However, each company had a different strategy for developing a technical solution to meet regulatory requirements. At the time, all the major utilities in the industry were desperately searching for such a solution in order to get approval for the construction of their planned offshore wind farms.

In Case E, the focal firm was dominated by a single entrepreneur. Before entering the wind energy industry, this individual had worked for foundries and aircraft manufacturers. After hearing about new technical requirements in the offshore wind energy industry, the entrepreneur invented a solution by creatively combining his technical knowledge gained in steel construction with the unique technical requirements of installing offshore wind turbines. The entrepreneur was not immediately successful, but he quickly found another solution. He adapted a technological principle that, at the time of the research, was well established in the field and used by the company's main competitor.

In this case, technology development took place largely in the mind of the entrepreneur, who essentially imagined technical solutions independently of established scientific knowledge, standardized engineering routines, or external partners. As predicted by P3, the entrepreneur relied on experience gained in other industries and adapted technical ideas from adjacent fields. The entrepreneur's main competitor followed a different strategy. This firm improvised collaborative trial-and-error learning and system testing during ongoing construction projects. The studied entrepreneur's firm did not pursue such a collaborative innovation approach, but instead relied on the individual creativity, determination, and technical imagination of its CEO. This creativity and determination emerged as the dominant mechanism shaping the technology development in case E.

In Case F, a more collaborative approach to the introduction of a technical solution in a new field was observed. The focal company was an engineering service provider specializing in the design and installation of foundation structures for drilling platforms used in the offshore oil and gas industry. The company was attempting to transfer an oil and gas technology to the wind energy industry by developing a quieter foundation process for the installation of offshore wind turbines. In contrast to Case E, this company developed a prototype by relying on professional offshore engineering skills. Based on a broad bundle of technological know-how as well as simulation-based engineering routines and logistical skills gained from "*decades*" of offshore construction projects, the company was highly experienced in combining the technical requirements of different project partners to develop creative solutions, as described in P3. This competence was key to the technology transfer from the offshore oil and gas industry to the wind energy industry.

In contrast to the individual entrepreneur in Case E, the focal firm in Case F strategically collaborated with external partners. In particular, it worked with scientists to gain access to science-based engineering routines and testing facilities to adapt its new foundation structure to the technical requirements of the offshore wind energy industry. In this way, the company was able to establish a collaborative innovation praxis that resulted in a technology suited to the unique requirements of offshore wind turbine installation. Thus, in this case, trust building based on collaborative engineering and science-based system testing appeared to be an effective mechanism of technology development. However, as in Case E, the engineering firm were unable to establish a stable position in the field because it barely partnered with a large utility willing to use the new technology in an offshore wind farm.

Thus, at the time of the investigation, neither company had established stable customer relationships with large utilities, which prevented these companies from establishing a strong position in the new field. It can be concluded that neither the reliance on individual skills (such as creativity, determination or imagination), as observed in case E, nor the reliance on professional offshore engineering skills, as in case F, is sufficient to successfully introduce a new technology and establish a firm as a trusted system supplier based on certified, proven technologies. Both companies did not establish a power position and their technologies remained prototypes. As a result, one firm was unable to prevail against its competitor (Case E), while the other firm remained excluded from offshore innovation networks (Case F). In both cases, the observed outcome was rooted in a lack of collaborative innovation praxis with a large utility willing to provide access to real-world system testing at sea.

Based on these findings, it could be argued that even in emerging technology fields, such as noise mitigation or quiet foundations in the offshore wind industry, new technologies tend to be introduced through hierarchical innovation strategies because utilities and wind farm operators select system suppliers, define membership rules, and provide access to collaborative offshore system testing, which is a prerequisite for adapting technical solutions to new environments. Only the ability to establish a stable position as a trusted, accepted and reputable system supplier ensures the survival of a development company in an emerging field.

8.4 Synthesis: The institutional barriers to collaborative innovation

The previous section summarized the empirical findings of this study. Based on these findings, this section analyses the institutional barriers to collaborative innovation.

The author argues that the key to managing collaborative innovation is the praxis of establishing shared standards for designing, building, and testing new technologies. In the case of new technologies, characterized by intricate technological interdependencies between components, this process is necessarily collaborative in nature and requires knowledge input into the firm's innovation processes from various fields of expertise outside the innovating firm. It has been expected that the praxis of establishing shared standards can normatively bind together different innovation partners despite the different self-interests associated with the respective actors' positions in the field (cf. Lawrence, 2010; Lawrence & Suddaby, 2006). Particularly in the case of radical innovations, the establishment of a common innovation praxis was seen as crucial for ensuring collaboration between previously unfamiliar innovation partners.

In short, the establishment of a collaborative innovation praxis was expected to play a key role in the management collaborative innovation. Shared working standards provide 'rules of the game' (e.g., design rules) and inform actors about the consequences of violating commonly accepted 'ways of doing things' (e.g., warranty claims). Working standards were defined in Chapter 3 as voluntarily decided rules or impositions of normatively connotated procedures and methods of technology development (Ortmann, 2014; Ahrne & Brunsson, 2010). In the context of this study on the wind energy industry, working standards refer to examples, models, levels, or norms for the design, construction, and testing of a new technology that is part of wind turbines, integrated into production processes, or used for the installation of offshore wind turbines. If this innovation praxis is not established, innovation projects are likely to produce a series of unintended outcomes, incurring costs as well as delaying and degrading quality. In the following, this argument is specified with regard to three different technology fields.

8.4.1 Incremental innovation: Incumbents are bound to existing technical standards

In the two examples of incremental innovation among the empirical cases studied in this book, a largely established praxis of collaborative innovation seemed to be visible. However, as both innovation projects were hierarchically controlled by a WTM, a collaborative innovation praxis characterized by openness to new solutions and equal cooperation based on knowledge complementarities and technical interdependence was hardly observed. Thus, coercive power appeared as the dominant strategy, which reduced the innovation project to a mere order development and also reduced the innovative potential of the two project networks as a whole.

These findings suggest that for incumbent firms such as large WTM, establishing an innovation praxis would mean integrating new and previously unknown technical standards and technology specialists into their corporate innovation processes. If they don't, the incumbents' own rules will limit their capability to change the technical standards that have served them well in the past, as Fligstein & McAdam (2011, p. 14) also note: "*[I]ncumbents are both products and architects of the worldview and set of rules they helped to create. They are now dependent on it, and this dependence limits their ability to imagine alternative courses of action*." As a result, when incumbents are not open to the contributions of other partners, they are not open to change and innovation.

8.4.2 Radical innovation: The inability to build coalitions with powerful actors

In the two cases of radical innovation, a coherent approach to establishing a collaborative innovation praxis was found only in single stages of the innovation process, such as the definition of technical requirements for a new rotor blade coating facility, or the material testing and science-based experimentation in the case of a 'wooden wind turbine'. In these examples, the project partners gained some control over the outcome of each stage by relying on personal trust between individuals. However, when it came to implementing the new technology, the peer-to-peer collaboration quickly gave way to more hierarchical, centrally controlled network relationships. This led to unintended outcomes such as time delays and serious quality defects.

To avoid such outcomes in the creation of radically new technologies, it would be crucial to establish a shared innovation praxis even in the later stages of the innovation process. For this, innovative component suppliers in established technology fields would depend on coalitions with powerful field actors who control technical standards and the 'rules of the game' (cf. Fligstein & McAdam, 2011, p. 7). In the two empirical cases of radical innovation studied, the rotor blade factory had to convince a specialist in automation systems to transfer his established expertise to the context of rotor blade manufacturing, while in the case of the 'wooden wind turbine' the start-up firm had to convince a licensing authority to certify its new design. In both cases, however, the focal firms were unable to build a stable coalition with these powerful actors, which might explain the observed outcomes.

8.4.3 Emerging fields of technology development: The lacking legitimacy of system suppliers

Similar to the cases of radical innovation, no coherent strategy of collaborative innovation was found in the last case pair of emerging technology development in the German offshore wind industry. In one case (noise reduction), an entrepreneur relied on individual technical imagination instead of (re)creating common working standards, while in the other case (a more quiet founding process), a professional offshore engineering firm could not establish a stable position in the field.

To introduce a new technology in an emerging field and to establish a shared innovation praxis, firms may need what Fligstein & McAdam (2011, p. 7) refer to as cognitive, empathetic, and communicative skills to secure the willing cooperation of others and to build the legitimacy needed to establish entirely new technical standards. In the words of Fligstein and McAdam (ibid.), socially skilled actors have the ability to transcend their own individual and group self-interest and consider the interests of multiple groups in order to mobilize support from those groups for a particular shared worldview. In the empirical case of a new field emerging around public regulations for minimizing noise emissions during the construction of wind farms, social skill would have enabled the two developers of a noise mitigation system and a quieter foundation process to build trust in the eyes of large utilities and regulatory agencies involved in the planning and permitting of offshore wind farms at the time. However, neither innovator was able to establish a stable position as a trusted, accepted and reputable system supplier.

Based on these findings, it can be concluded that the praxis of establishing the regulatory, normative, and cultural-cognitive foundations of firm openness is key to the development and adoption of complex new technologies. In the words of Scott (2008, p. 48), an interorganizational shared innovation praxis together with its associated activities and resources, provides stability and meaning to social life. In this context, to the collaborative development of new technologies. If the establishment of such a praxis across organizations is hindered, collaborative innovation are likely to miss their objectives.

This brings us to an answer to the research question formulated in Chapter 1 of this book. The author seeks to contribute to sociological theory-building around the management issues of 'knowledge integration'. Indeed, theory building should be a primary goal of all qualitative research based on a multiple case study design, meaning that the analyst should derive valid, relevant, and testable hypotheses from the empirical material (Eisenhardt & Graebner, 2007; Eisenhardt, 1989). This study examines the relationship between innovation project outcomes and institutional barriers. In empirical cases, such results took the form of untapped innovation potential, serious quality defects, or excessive delays. The author identifies three institutional barriers to collaborative innovation:

1. Powerful firms that have control over incumbent technologies whose architecture could be changed by innovation do not grant legitimacy to innovative firms that might be able to introduce new technical standards. This would result in loss of power over industry technical standards. Innovative companies should therefore engage in industry-specific discourse in order to mobilize support for their innovative position.
2. Incumbents do not integrate innovative solutions from unfamiliar fields of expertise into their innovation practices. This institutional barrier is evident when incumbents use coercive rules to control technology development. In this way, the incumbent firms are able to retain full power over the praxis of innovation. On the other hand, established players could bridge the gap to innovators with the help of boundary spanners with professional experience in several specialist disciplines (Carlile, 2004).
3. Innovative firms seeking to introduce radical innovations may not be able to secure the support of powerful actors such as incumbents or regulatory bodies (e.g., certification/licensing agencies) that control existing standards for developing technology in an established field. The ability to gain support from incumbents would in turn be a factor in the overcoming of this institutional barrier. This could happen when innovative firms use intermediary institutions to partner with established firms or to

reduce regulatory uncertainty and integrate normative expectations into their solutions (Borrás & Edler, 2014).

In summary, strategies for overcoming institutional barriers in the context of collaborative innovation are not purely technical in nature. Rather, they require social-strategic skills in the sense of Fligstein & McAdam's (2011) Social Skill Theory: the ability to understand the power positions of influential actors, the ability to form coalitions, to balance interests and to establish common interpretations of innovation. Companies that are aware of this social dimension significantly increase their chances of success in collaborative innovation processes. Ideally, future research should test these findings with more empirical cases.

8.5 Theoretical relevance

The study shows that the management of collaborative innovation is not purely technical in nature, but must be understood as a social praxis. It is essentially about establishing common working standards that hold the innovation team together despite differing interests and cognitive frames. This is an important development of the open innovation approach (Chesbrough, 2003, 2006), which has so far neglected the institutional and social context of innovation projects. While open innovation focuses on the benefits of external knowledge sources, this study shows that collaborative innovation often fails to realize its potential due to institutional barriers shaped by societal expectations of technology development and power dynamics between the actors involved.

The study also makes an important contribution to the theory of knowledge integration by showing that not only do knowledge boundaries need to be bridged, but that the key to knowledge integration lies in a praxis that overcomes barriers of cognition and power, which must be consciously constructed (Grant, 1996; Berggren et al., 2011). By examining three collaborative innovation praxis (imposing technical standards, relying on personal relationships, and individual imagination), we show how knowledge integration can succeed or fail in different innovation contexts. In particular, relying on personal trust seems to be an inferior innovation strategy.

With regard to knowledge integration, the book also extends our understanding of the concept of "epistemic communities" (Håkanson, 2010). It is shown that collaborative innovation practice is not only the result of knowledge sharing, but is also the result of shared norms and standards of technology development.

The author of the book has used field theory to understand collaborative innovation as an institutionally embedded social practice (Fligstein & McAdam, 2011). The three innovation contexts (incremental, radical, emergent) reflect different institutional conditions under which organizations have pursued specific innovation strategies for knowledge integration.

This book builds on the work of North (1990) and Elster (2007). It argues that working standards as informal institutions that constrain and structure agency, and that the distinction between formalized norms (e.g. through certification) and implicit rules (e.g. social norms in the innovation process) is particularly relevant for innovation management in regulated industries such as wind energy.

Finally, the study shows how powerful actors (e.g. large companies or regulatory authorities) can enable or hinder innovation efforts by outsiders in fields by setting standards or controlling access to knowledge and networks. This book, therefore, also expands our understanding of the concept of social closure by showing that organizations are closed not only by hierarchies or market mechanisms, but also by technical standards, regulatory requirements, and professional norms. This can be well observed in the contexts of collaborative innovation.

Overall, this book makes an important contribution to innovation and organizational theory by showing that implementing collaborative innovation requires a social practice that is characterized by shared norms, social closure, and interorganizational power dynamics. This opens new perspectives on open innovation, institutional barriers, and interorganizational collaboration for the study of innovation management.

8.6 Practical relevance

The findings in this book are also relevant to practitioners. The applied sociological perspective provides a deeper understanding of how to manage collaborative innovation. Specifically, the book's author shows that companies must develop not only technological but also social strategies to overcome power asymmetries and effectively implement innovation projects. Encouraging and moderating the power dynamics and the social process of involving all relevant innovation partners would then be a core capability of innovation management.

The findings of this book also sensitize practitioners to the institutional work involved in collaborative innovation. Particularly in the case of radically new technologies, technology development requires not only the negotiation of shared working standard, but also the establishment of social norms such as a sense of duty, trustworthiness, secrecy, solidarity, etc. The existence of such social norms could provide informal rules of collective behavior of organizations. The existence of such social norms can compensate for the social conflicts between innovation partners that are likely to arise when diverse actors come together to develop radically new, complex technologies.

It has also become clear that regulatory authorities have a crucial role to play in radical innovation, as they can either facilitate or impede the innovation process by means of standards and certification procedures. It has also become clear that innovation networks, which are composed of several organizations, have to be shaped not only by the knowledge, but also by the social and political skills of the actors involved. This is a crucial innovation capability.

The empirical results also show that digital solutions can have an important role in the facilitation of knowledge integration in collaborative innovation projects. In particular, it is emphasized that the digitization of technical information using standardized simulation methods (e.g., Finite Element Methods (FEM), Failure Mode and Effects Analysis (FMEA)) supports combining and developing knowledge. Future research should deepen this aspect.

8.7 Limitations and implications for future research

While this study has valuable insights into the social processes of collaborative innovation, it has several limitations that should be taken into account in future research.

First, the study focuses on companies outside of large research and development (R&D) departments and is based on six empirical case studies from the wind energy industry. Only the case of a robotics-based rotor blade coating facility was located within a large WTM, albeit with little support from the central R&D department. Apart from this case, all three types of innovation contexts included mostly newcomers to the wind energy industry. This means that key players such as established wind turbine manufacturers – such as Enercon, Vestas, Siemens or General Electric – are largely ignored. Here, studies can be conducted to examine whether incumbent firms, with their innovation networks and existing power structures, manage collaborative innovations differently from newcomers.

Second, the qualitative case study method allows for in-depth insights into social dynamics of innovation, but is prone to selective perception and retrospective bias. Furthermore, a simple classification of innovation types (incremental, radical, emergent) has been used so far. Other relevant categories have not been systematically considered. For example, innovation classification could better distinguish between technical components, technological architectures, and service innovations, as the latter require more collaboration. Also, quantitative or mixed-methods approaches may be appropriate to investigate causal relationships between innovation practices and project outcomes.

Third, the study emphasizes the importance of social processes. However, the role of power and strategic behavior of incumbent actors remains unclear. The rules of the game are often in the hands of powerful companies or regulatory authorities. They can either be the promoters of innovation or the controllers of innovation networks through institutional barriers. For example, the case studies show that dominant wind turbine manufacturers force their suppliers into a purely contractual relationship through strict technical standards. This limits the potential for collaborative innovation. Studies that show how incumbents deliberately set innovation standards in order to secure competitive advantage could be informative here.

In summary, several avenues of research can be derived from the limitations of the study: 1) Cross-industry analyses can verify the generalizability of the results. 2) Quantitative studies could reveal the causal relationships between innovation efforts and project outcomes. 3) Power and political perspectives should be included to analyze strategic interests in innovation networks.