2. The management of collaborative innovation

This book examines the barriers to collaborative innovation. Firms establish social relationships with other formally independent organizations rather than developing and introducing complex technologies in isolation. As shown in the introductory chapter, from a management perspective, the introduction of a complex technology is primarily a matter of its commercialization in markets or its application in production lines (Dodgson et al., 2014; Edquist, 2005; Fagerberg, 2005). However, this chapter critically assesses what management research tells us about the barriers to collaborative innovation, as management scholars are intensively discussing how firms should manage knowledge flows across organizational boundaries.

Innovation management research tends to focus on how collaboration enhances firms' ability to innovate or solve problems. Since the seminal work of Chesbrough (2003), the concept of open innovation has postulated that inter-firm collaboration is a straight path to commercial success, so the first part of this chapter reviews the debate on open innovation. This means that although the open innovation literature does not explicitly address institutions, management scholars analyse how firms manage interfirm relationships. They also analyse how firms can use external knowledge to increase their own innovativeness, and how formal and informal rules of knowledge protection can affect a firm's propensity to collaborate with external stakeholders.

Another management debate, that of knowledge integration, is introduced in the second part of this chapter. This approach has less normative connotations than open innovation. Its proponents take a more nuanced view of the benefits of collaboration. They acknowledge that innovation projects can lead to unintended outcomes. More importantly, while open innovation remains a management ideology, the knowledge integration approach is more theory-driven. It is mainly based on the knowledge-based view of the firm (KBV). Rather than simply looking for success stories, the theory allows us to derive hypotheses about the outcomes of innovation projects that can be systematically tested using empirical data.

At the end of the chapter, the research gap of this study is presented. This book contributes to the debate on innovation management by identifying the institutional barriers to collaborative innovation. The author of this book will argue that managing innovation projects can be better understood as a social process: in order to 'bind' specialists together, despite their potentially conflicting cognitive orientations and self-interests, innovation partners need to establish a shared praxis of collaboratively designing, building and testing a

new technology (cf. Lawrence, 2010; Lawrence & Suddaby, 2006). Institutional barriers may then explain unintended outcomes.

2.1 Open innovation – A straight road to success?

In the introductory chapter, the introduction of complex technologies was described as being dependent on the collaboration of formally independent organizations. In the field of innovation management research, the concept of open innovation is prominently discussed as how focal firms (that initiate innovation processes and commercialize a new technology) collaborate with heterogeneous partners. This debate on open innovation is hard to ignore. Since its introduction, the number of contributions has increased significantly. A review by Chesbrough & Bogers (2014) found thousands of new contributions each year, citing Chesbrough's (2003) seminal work.[12] Therefore, the author of this book only reviews studies that provide insights into the praxis of collaborative innovation.

The open innovation literature identifies various potential collaborators, such as material or component suppliers, technology users or customers, universities or research institutes, competitors and intermediaries.[13] The latter provide knowledge-intensive services.[14] Open innovation scholars consider

12 For a literature review, see West et al. (2014); a review of quantitative studies of open innovation is provided by Schroll & Mild (2012).

13 The literature considers intermediaries as particularly helpful for SMEs because they provide support in establishing collaboration networks and rendering cooperation among partners effective (Lee et al., 2010; Katzy et al., 2013). Intermediaries can actively contribute unique knowledge-intensive services to new product development (NPD), such as scouting new technologies and markets, generating concepts and designs, and supporting engineering and testing (Czarnitzki & Spielkamp, 2000). Technology transfer offices, business incubators or entrepreneurship centers provide complementary knowledge that smaller firms do not possess (Katzy et al., 2013).

14 Different forms of more or less collaborative innovation are referred to in the management literature. For example, open innovation is distinguished from other forms of distributed (or horizontally integrated) innovation processes by Alexy & Dahlander (2014). For example, in contrast to user innovation, the open innovation approach is concerned with producer firms that create new technological designs and deliver them to consumers in the form of goods and services (cf. Baldwin & von Hippel, 2011). In some cases, the producing firm may use existing technological solutions developed by external parties to improve its own technologies. In other cases, a producing firm might use product concepts from research institutes as inputs and transform them into a marketable good (Bogers & West, 2012). Alternatively, a producer firm may be in search of new needs that fit with internally

collaboration imperative. They argue that in today's business environment, the job mobility of highly skilled workers is increasing, private venture capital for the commercialization of new products is more readily available, the time-to-market span of innovations is becoming shorter, the technological expertise of firms' customers and suppliers is increasing, and internet-based communication and social media facilitate collaborative work across organizations (cf. Dodgson & Gann, 2014; West & Bogers, 2014). As a result, management scholars are anticipating the advent of the open innovation era.

For sociologists, the open innovation approach is insufficient for the analysis of innovation processes in firms. Blättel-Mink & Menez (2015, p. 191), for example, criticize the management approach for relying on success stories that 'prove' the coming paradigm shift towards open innovation, rather than deriving theory-based assumptions about interfirm collaboration. Indeed, there are management scholars who euphorically see openness as "*a new dimension of competition*" (Henkel et al., 2014, p. 879) or express the superiority of this innovation model compared to closed ones. Collaboration is seen as a management strategy to increase innovativeness, as Cheng & Huizingh (2014, p. 1248) argue: "*Involving external parties in innovation projects, acquiring or exploiting intellectual property, and actively managing a firm's various collaborative relationships seems to be an effective means to increase innovation performance*." Despite these highly normative associations between collaboration and innovativeness, empirical examples of open innovation provide some insights into the praxis of managing learning and innovation across organizational boundaries.

The basic idea of open innovation is quite simple: its proponents assume that knowledge flows across organizational boundaries increase innovativeness if they are purposefully managed. Through collaboration, innovative firms can take advantage of external knowledge and transform it internally into new products or services that can be sold in markets (Bogers & West, 2012; Chesbrough, 2006a). From this perspective, a collaborative innovation is successfully introduced once a focal firm has commercialized a new technology that contains external inputs (such as ideas, concepts, solutions, needs). As summarized in the following definition, a firm's innovation process is considered to be 'open' if intellectual property (IP)[15] flows deliberately into and/or out of the firm:

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available ideas. In any case, open innovation assumes that interfirm collaboration is the locus of innovation.

15 Intellectual property is defined as "*registered or unregistered IP ownership and usage rights, which control the commercial use of the shared knowledge*" (Granstrand & Holgersson, 2014, p. 20).

> *Open innovation refers to managing "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Open innovation assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology."* (Chesbrough, 2006a, *p. 1)*

As Table 1 shows, the literature distinguishes four types of openness. First, firms can acquire a new technology through purchase or license from markets. Second, they can source ideas by collaborating with private or public actors such as start-up firms or external professional or scientific communities. Third, firms may simply sell their products or services on markets or, last but not least, they may reveal their ideas to outsiders (Alexy & Dahlander, 2014). Coupled innovation describes innovation processes where an innovating firm combines different openness. Instead of the dominance of one firm in the innovation process, coupled innovation is typically associated with knowledge interdependencies and complementarities between innovation partners (Chesbrough & Bogers, 2014).[16]

Table 1: Types of open innovation processes

	Inbound innovation	**Outbound innovation**
Pecuniary	Acquiring	Selling
Non-pecuniary	Sourcing	Revealing

(Alexy & Dahlander, 2014; Dahlander & Gann, 2010)

However, the open innovation approach hardly addresses the question of how to explain the outcome of innovation processes, as this book aims to do. Instead, it provides studies that support the highly normatively connotated image of an imagined future in which all firms must open up their innovation processes to external knowledge.

16 In coupled innovation, knowledge is ostensibly controlled by different partners who together form dyadic partnerships or networks (Alexy & Dahlander, 2014; Chesbrough, 2006a; Tucci et al., 2016; West & Bogers, 2014). For example, two or more organizations may collaborate in strategic alliances, joint ventures or R&D consortia. They may also collaborate in more informal networks. However, Cassiman & Valentini (2015) critically discuss the complementarity of inbound and outbound innovation activities (e.g. buying and selling) in an empirical study on Belgian manufacturing firms. The authors do not find any confirmation of a relationship of complementarity. In fact, "*how the different types of openness are related to each other*" (Alexy & Dahlander, 2014, p. 447) is considered to be a research gap in the field of open innovation.

Already in his seminal work, Chesbrough (2003) notes that in the twentieth century, the establishment of sophisticated internal R&D laboratories has been the dominant innovation strategy of large firms such as General Electric (cf. Idelchik & Kogan, 2012). This also entailed creating barriers to entry and defining clearly delineated organizational boundaries between insiders and outsiders of corporate innovation processes (Dahlander & Gann, 2010; West & Bogers, 2014; West et al., 2014). This supposedly old-fashioned model of 'closed innovation' suggests that innovating firms keep their R&D labs closed and their best people in-house. They protect their intellectual property and improve their organizational capabilities, thereby increasing the efficiency of their innovation processes and maintaining their position as technology leaders. The working relations in such firms are typically characterized by a hierarchical organization of decision making as well as a close temporal sequence of managerial control (Bogers & West, 2012).

However, open innovation proponents argue that this closed model is outdated. In the 21st century, large and established technology firms in all industries are increasingly required to open up their internal knowledge silos to external stakeholders and to manage the flow of knowledge in and out of the firm. The reward for doing so is likely to be shorter innovation cycles and reduced internal R&D efforts. By leveraging external knowledge through collaboration, firms accelerate internal innovation processes, improve efficiency by minimizing investment in internal R&D facilities, reduce time-to-market, discover technological alternatives faster, and specify design features or technical interfaces more easily. Empirical evidence seems to prove that the age of open innovation has arrived (Alexy & Dahlander, 2014). Even technology companies such as Intel, Microsoft, Sun, Oracle or Cisco are increasingly using the "*research discoveries of others*" (Chesbrough, 2003, p. xix). For example, technology companies such as IBM, Novell or NOKIA use software knowledge created by open source communities (Alexy & Reitzig, 2013). Pharmaceutical companies such as Bayer actively use the "*creative potential of external partners*" (Dekkers, 2014, p. 69) by collaborating with members of scientific communities or integrating innovative start-ups into their product development processes (cf. Nakagaki et al., 2012). In all industries, as management science claims, open innovation is a straight path to commercial success, but "*little is known about the failures of open innovation*", as West & Bogers (2014, p. 828) point out in their literature review on open innovation.

Studies provide empirical evidence that collaboration is positively related to higher innovation performance.[17] However, some management scholars

17 Open innovation scholars often link collaboration to innovation performance. For example, Cheng & Huizingh (2014, p. 1235), based on empirical data from a large

show that this relationship cannot be simply assumed. For example, using survey data from 221 Belgian manufacturing firms, Faems et al. (2005) found that collaboration increases sales of new or improved products. However, the innovation outcome differs depending on the type of collaboration. While collaborating with customers or suppliers increases the innovating firm's ability to exploit existing technologies, collaborating with universities and research centers makes it easier to benefit from exploring new technical knowledge.

Based on panel data from Irish manufacturing firms, Love et al. (2013) found that the positive effect of collaborating does not need to be present from the start. Rather, firms must learn to improve their innovation performance through collaboration on the basis of prior experience. Thus, the link between collaboration and innovation performance postulated by the open innovation approach cannot simply be assumed. Rather, innovating firms may – over time – learn to exploit external knowledge through collaboration with heterogeneous partners. They will then have a better understanding of how to select appropriate partners or how to manage multiple relationships.

Another study by Walsh et al. (2016) points in a similar direction. They also find that the link between collaborating and innovating cannot be simply assumed, because the praxis of collaborating differs. For example, using survey data on inventions by US firms, the study shows that vertical collaboration between firms and their suppliers or customers during the invention phase increases the likelihood of successful commercialization of an innovative technology. Horizontal collaboration, especially with universities, does not. This may be because vertical collaboration provides the innovating firm with more specific knowledge of customer needs or supplier capabilities, whereas collaboration with universities provides knowledge that is much broader (cf. Nieto & Santamaría, 2007; Un et al., 2010).

More analytical approaches to the management of open innovation ask the question of why top managers should voluntarily give up control over their intellectual property (Alexy et al., 2017). If technology firms are defined as bundles of valuable, rare, inimitable and non-substitutable resources such as knowledge and information-as predicted by the knowledge-based view of the firm (KBV)-firms must control these resources to remain competitive (cf. Henkel et al., 2014). Empirical evidence shows that firms like IBM, Novell or NOKIA share proprietary knowledge with outsiders like OSS communities (Alexy & Reitzig, 2013).

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service firm in Taiwan, found that open innovation activities positively affected four measures of innovation performance: "new product/service innovativeness, new product/service success, customer performance, and financial performance".

An explanation for these findings can be found in the management literature. It views firms as bundles of complementary resources and concludes that the creation of a common resource pool that can also be shared with rivals (e.g. source codes in software communities) and the separation of this common resource pool from exclusive, internal knowledge could influence a firm's propensity for collaborative innovation. In this way, there is no contradiction in established management theory with strategic openness. On the contrary, a firm might gain superior information or complementarities from competitors if it succeeds in creating a common resource pool that can be shared even with rivals. Thus, management scholars conclude: 'strategic openness' can be seen as an economically rational management decision to selectively appropriate external knowledge. In practice, collaboration with research consortia or cooperative standardization may be established as a new industry norm to appropriate knowledge and outperform those competitors who are excluded from the shared knowledge pool.

In conclusion, empirical findings suggest that an increase in collaborative innovation cannot simply be assumed, as is often done by open innovation scholars, in contrast to the highly normative image of open innovation. Moreover, collaborating does not automatically lead to (commercially) successful technological innovations. Instead, the outcome of collaborative innovation may be influenced by the structural characteristics of collaborations, such as the specificity of the knowledge exchanged or the type of collaboration. These findings support the author's main argument: Institutionalized 'rules of the game' or 'ways of doing things' strongly influence the outcome of innovation projects.

2.1.1 Rules and practices of IP management

The previous section introduced the management approach of open innovation. It was shown that the positive relationship between collaboration and innovativeness, which has a strong normative connotation, *cannot* be simply assumed. Empirical studies suggest that structural conditions such as the type of collaboration (vertical, horizontal) or knowledge specificity (broad, specific) have an impact on the outcome of open innovation projects. The author of this book argues that in order to identify the institutional barriers to collaborative innovation, it is necessary to understand the 'rules of the game' or 'ways of doing things' of innovation projects.

To the best of the author's knowledge, the open innovation literature rarely discusses the praxis of collaborative innovation. Management scholars only suggest that the extent to which innovating firms open up their innovation processes to outsiders may be affected by formal and informal knowledge

protection practices. The implication is that firms have to establish effective appropriability rules in order to minimize the risk of knowledge leakage that might occur in collaboration with outsiders (Alexy & Dahlander, 2014; Henttonen et al., 2016) Such rules of knowledge protection then increase firms' propensity for collaboration.

Collaboration as a business strategy paradox is discussed by other open innovation scholars. If it is true that collaborating is the best way to succeed, collaborating is the best choice. However, opening up the firm's boundaries to outsiders increases the risk of unintended knowledge spillovers. This can weaken an innovating firm's ability to capture value from proprietary knowledge. This risk has been referred to as the paradox of openness by Laursen & Salter (2014). For example, knowledge leakage can occur when a partner who has been part of a joint innovation project collaborates with a competitor after the project has been completed (Ortmann, 1999; Takeichi, 2002). There is discussion in the literature about practices and strategies for dealing with this 'paradox of openness'.

Firms are faced with two choices. On the one hand, a firm can prevent knowledge spillovers by protecting its intellectual property, defining the ownership of exclusion rights (patenting, licensing) and securing rents from innovations (cf. Bogers et al., 2012; Veer et al., 2016). In the day-to-day praxis of open innovation, such formal or informal rules of knowledge protection might reduce a firm's risk perception of collaboration with outsiders and thus increase its propensity to share proprietary knowledge. On the other hand, a firm might have the perception that too much knowledge protection would make it less attractive as an innovation partner. In this case, it might give up control over parts of its intellectual property (Alexy et al., 2017). Management scholars call this strategic openness. They consider it a rational decision.

There is empirical evidence in the literature to support both strategies. Arora et al. (2016) conclude that a firm's decision to adopt one of the two strategic options depends on its technological leadership in a sector, based on survey data from UK firms that use patents at different intensities. The authors find that technology leaders, who face a higher risk of knowledge spillovers, are more likely to patent than technology followers, who have less proprietary knowledge. These findings suggest that a firm's position in the industry, e.g. as a technology leader, may influence its decision to use formal precautions to protect knowledge.

Other scholars discuss the extent to which formal rules for protecting knowledge increase firms' propensity to engage in collaborative innovation. These scholars have found that in R&D projects the risk of imitating knowledge is not evenly distributed, but depends on the stage of the innovation process as well as the partners involved (Veer et al., 2016). Moreover, even

when appropriability regimes exist, "*[n]oncontractual social relations are important complements to contractual relations*" (Granstrand & Holgersson, 2014, p. 25). Apparently, the existence of formal appropriability regimes alone does not sufficiently explain the conditions under which firms decide to collaborate with outsiders and share proprietary knowledge.[18] The management literature acknowledges that informal relationships, non-contractual agreements, trust and secrecy may also influence the degree of openness.

Veer et al. (2016) criticize that the link between appropriability regimes and openness is often discussed in the context of dyadic relationships. However, open innovation research analyses portfolios of heterogeneous organizations engaged in joint R&D projects. Here, informal knowledge protection mechanisms such as trust or secrecy may be even more important than formal knowledge protection measures (Henttonen et al., 2016). Even patents do not necessarily have to facilitate collaborative innovation. They can work both ways, as both enablers and inhibitors of open innovation (Laursen & Salter, 2006). Only for industry newcomers, patenting of proprietary knowledge may act as an incentive to engage in collaborative innovation in order to gain access to complementary knowledge and resources (Zobel et al., 2016).

A coherent understanding of how appropriability regimes influence firms' propensity to collaborate is not provided by the empirical findings summarized above. Nor do they have any bearing on what influences the outcome of innovation projects. This is why some management scholars call for more theory-led studies on how appropriability regimes relate to managing open innovation. Alexy & Dahlander (2014), for example, stress that legal definitions of ownership and use rights are not effective in all contexts. Intellectual property rights (IPR) may facilitate the contractualization of collaboration between innovation partners in contexts of "*clearly delineated boundaries*" (ibid., p. 451). On the other hand, if the boundaries between innovation partners are unclear and partners have difficulties in defining what knowledge they have used in other projects, the legal conditions for collaboration may prove problematic.

Granstrand & Holgersson (2014) take a similar view. They emphasize that in coupled innovation contexts, characterized by high knowledge interdependence and reciprocity between partners, knowledge use rights and ownership can be easily distributed between different organizations. The authors acknowledge that in empirical reality, different forms of IP management are conceivable. Thus, managers need to negotiate appropriate practices that fit

18 Appropriability regimes are defined as conditions such as the ownership of exclusion rights (patents) which determine how firms can create value from innovation (Pisano & Teece, 2007).

context-specific conditions. Management scholars therefore call for future research to 'clarify the relevance of [appropriability] mechanisms under different conditions' (Zobel et al., 2016, p. 327). Without such theory-guided analysis, management scholarship is likely to remain stuck in mere descriptions of decision making, managerial choices, and optimization objectives, rather than explanations.

This section has shown that the empirical studies hardly reveal how rules or practices of knowledge protection influence collaborative innovation projects. In fact, to the author's knowledge, there is only one empirical study that is more theory-driven. It shows how organizational practices might mediate openness. Based on survey data from 169 Danish manufacturing and service firms, Foss et al. (2011) argue that a firm's organizational practices positively influence the likelihood that customer knowledge is used to commercialize new products. The authors point to practices such as the delegation of decision rights to R&D personnel, the intensification of vertical and lateral communication between customers and internal R&D experts, such as through key account managers, and the provision of incentives for employees to acquire external knowledge and share it with colleagues in internal R&D departments. The authors conclude: Such organizational practices can mediate the extent to which an organization is able to use external knowledge to innovate new technologies. Such practices are expected to both "*hinder and facilitate interaction with customers*" (ibid, p. 983).

In conclusion, studies on open innovation have discussed appropriability regimes as a factor influencing the propensity of firms to engage in collaboration. However, the literature often lacks a theoretical underpinning. A deeper understanding of how such rules or practices of knowledge protection explain the outcome of innovation projects is lacking. In order to improve our understanding of how open innovation projects are organized, some management scholars call for a more theory-driven analysis. Other scholars ask how the internal design of organizations facilitates exploiting external knowledge. These scholars suggest the analysis of structural conditions such as the internal division of labor, incentives for information sharing, and individual autonomy to share proprietary information with internal and external specialists.

2.1.2 Preliminary conclusions: Blind spots in the open innovation debate

The literature on open innovation generally assumes that inter-firm collaboration is positively associated with better products, services or processes. As Table 2 shows, various factors influencing the outcome of innovation projects have been identified in empirical studies on open innovation. Walsh et al. (2016) and Faems et al. (2005) have shown that the outcome of innovation

projects depends on the type of collaboration, such as vertical relationships with suppliers or horizontal relationships with universities or competitors. Nieto & Santamaría (2007) and Un et al. (2010) add that such collaborations actually differ in the specificity of knowledge. They argue that the specific knowledge of suppliers has a positive impact on the outcome of innovation projects, while the broader knowledge of universities has a less positive impact.

Another debate discusses how appropriability regimes or formal as well as informal knowledge protection rules might influence a firm's propensity to collaborate (cf. Alexy & Dahlander, 2014; Henttonen et al., 2016; Laursen & Salter, 2014). Some studies are more theory driven. Strategic management studies such as Alexy et al. (2017) or Alexy et al. (2016) argue that the voluntary relinquishment of control over proprietary knowledge is a rational managerial decision if it excludes competitors from shared knowledge pools. Foss et al. (2011) argue that organizational design (e.g. collaboration practices) mediates external knowledge use.

However, it is difficult to derive a coherent picture of collaborative innovation praxis, as the open innovation debate is dominated by empirical case studies. Open innovation management scholars themselves acknowledge that companies prefer to trumpet success stories. Some management scholars call for a better link between open innovation and strategic management theory in order to explain how firms can benefit from openness (Vanhaverbeke & Cloodt, 2014). Similarly, Alexy & Dahlander (2014) argue that collaborative innovation's lack of theoretical embeddedness prevents it from explaining under which conditions firms share resources.

These conclusions agree with Gambardella & Panico (2014), who found that the open innovation literature lacks an understanding of the institutional conditions under which firms engage with outsiders. These 'contextual factors' (Garriga et al., 2013, p. 1142) or 'boundary conditions' (Cassiman & Valentini, 2015, p. 1045) are barely visible in the open innovation debate, despite scholars emphasizing that 'industry context matters' for understanding forms of open innovation (Garriga et al., 2013, p. 1140).

Most importantly for this book, as Bogers & West (2012, p. 65) put it: "*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.*" Overall, the open innovation management literature cannot explain the unintended outcomes of innovation projects due to its reliance on single case studies. This book considers this lack of theoretical foundation as a 'blind spot' in open innovation research. Therefore, sociology can advance our understanding of the management of open (collaborative) innovation.

Another concept of managing complex innovation projects is introduced in the next section. Knowledge integration management explicitly considers theoretical considerations such as knowledge boundaries as institutionalized barriers to collaborative innovation, in contrast to open innovation. Such scholars look for "*more or less formal mechanisms for the coordination of behavior and the achievement of goals when operating in the context of changing and uncertain contingencies*" (Tell, 2017, p. 8). How innovation projects are managed, and why they produce unintended outcomes may be better understood through this more social theory-led approach.

Table 2: Factors influencing the outcome of open innovations

Factors	**Authors**
Type of collaboration (e.g. vertical, horizontal)	Faems et al., 2005; Walsh et al., 2016
Specificity of the knowledge exchanged among partners	Annique et al., 2010; Nieto and Santamaría, 2007
Appropriability regimes and knowledge ownership rights (e.g. licensing, patenting)	e.g. Alexy and Dahlander, 2014; Henttonen, 2016; Laursen and Salter, 2014
Rationality of openness as a management decision to outperform competitors	Alexy et al., 2017, Alexy et al., 2016;
Organizational practices that mediate the use of external knowledge	Alexy and Reitzig, 2013; Foss et al., 2011

2.2 Key objectives of collaborative innovation management

Management research underscores the importance of integrating external knowledge and technologic sub-systems in achieving a competitive advantage for the company and enhancing the innovative capacity of business partners along the value chain (Gurca et al., 2020; Grant, 1996 a, b). This viewpoint lends support to the author's rationale behind the adoption of a social science perspective, which aims to examine the institutional barriers to collaborative innovation and knowledge integration.

As mentioned in the preceding section, the open innovation approach provides empirical insights into how firms manage knowledge flows across organizational boundaries. However, it must be noted that the approach is 'blind' to the institutionalized conditions of collaboration, as it is preoccupied with the highly normatively connoted positive association between collaboration and innovation.

In contrast to open innovation, the knowledge integration management debate recognizes that institutionalized conditions, in particular epistemic communities, can act as barriers to collaborative innovation. How firms can rely on routines, rules or standards to increase the efficiency of learning and innovation. Therefore, the integration of knowledge is considered to be a primary objective of collaborative innovation (Caccamo et al., 2023; Tell, 2011).

2.2.1 Knowledge boundaries – The cognitive barriers of collaborative innovation

The management approach of knowledge integration is rooted in management theories. In particular, the knowledge-based view of the firm (KBV). From this perspective, firms are bundles of "*valuable, rare, inimitable and non-substitutable (VRIN) resources*", including intangibles such as knowledge or information (Alexy et al., 2017, p. 4). Firms are not seen as static, black-box entities that are part of abstract economic production functions, but as internally building 'competencies'[19] or 'capabilities' that enable them to manage tacit knowledge sharing better than buyer-seller relationships in markets or loose informal collaborations (Cohen & Levinthal, 1990; Grant, 1996 b, a; Håkanson, 2010). From this perspective, firms instrumentally use decision-making rules, problem-solving routines or standards for testing or production to coordinate knowledge sharing within and across firms.

The management literature emphasizes specialization as a problem of innovation management. In modern economies, knowledge is becoming more and more specialized and dispersed. As a result, management scholars argue: The strategic challenge for firms is to build capabilities to integrate specialized knowledge. The management of learning and innovation within firms is directly affected by increasing specialization. On the one hand, the efficiency of intra-firm problem solving increases as a result of knowledge specialization and more complex division of labor. According to management theory, efficiency is the primary goal of economic organizations.[20] On the other hand, the specialization of knowledge within and across firms creates social groups that

19 Competence is defined as follows: "Competence is a generative ability of actors or systems to master concrete tasks and solve problems, but in doing so to make use of general knowledge that transcends the situation (own translation)" (Sydow, 2014a, p. 311).

20 For example, strategic management scholars such as (Grant, 1996b, p. 115) point out: "*[E]fficiency in organizations tends to be associated with maximizing the use of rules, routines and other integration mechanisms that economize on communication and knowledge transfer, and reserve problem solving and decision making by teams to unusual, complex, and important tasks.*"

are cognitively separate. Sociologists have referred to these groups as epistemic communities. This is because their members share rather exclusive cognitive frames of reference, as the definition below makes clear. Management scholars now believe that such institutionalized differences between experts such as engineers, scientists, lawyers or top managers need to be 'bridged' in order to achieve knowledge integration.

> *Epistemic communities consist of individuals with identical or similar "frames of reference" and cognitive "orientation systems." These are associated with specific social roles, such as those of different occupational groups, and are acquired in a process of cognitive socialization, usually through a combination of formal training and on-the-job experience.* (Håkanson, 2010, *p. 1807)*

In the classical concept of knowledge integration management, tacit knowledge in the heads of experts is seen as a management problem. More recent contributions to knowledge integration management point to institutionalized structures such as the epistemic communities mentioned above. Typically, such communities consist of those belonging to a professional or scientific discipline and interacting on a regular basis. Within such communities, interactions run rather smoothly because the members of the community are similar in terms of their epistemic backgrounds in terms of individual training, tacit knowledge, personal experiences, theories, language, identities and value systems. Overall, they share a common frame of reference. This makes it easier for them to reach agreements or compromises. Thus, within such communities, the theory predicts, it is easier to justify and legitimize technical solutions than it is across these communities, as summarized by Tell (2017, p. 22):

> *Specialization into epistemic communities creates knowledge boundaries, which, in turn, creates the need for knowledge integration. These knowledge boundaries arise from the knowledge frames shared by epistemic community members. These frames, which are applied by individuals, imply the existence of shared cognitions and social processes involved in justification and legitimacy.*

Conversely, management literature suggests that the daily activities of knowledge sharing can become problematic when complex problems arise, such as the introduction of a new technology, and experts from different professions and organizations with different epistemic backgrounds have to work together. Due to the expected cognitive differences, which scholars such as Tell (2017) metaphorically describe as knowledge boundaries, communication, interactions and collaborations may be disrupted or even turn into political conflicts.[21] The management literature argues that the establishment of shared cognitions is a crucial task in the context of complex technologies.

21 The literature makes several suggestions of how to conceptualize boundaries among (potential) innovation partners. In the case of product development teams within

From this perspective, the whole process of collaborative innovation is influenced by cognitive structures (frames). Reconciling potentially conflicting assumptions, expectations and knowledge about how the future technology will work and be used in a particular context may then be a critical management task. Orlikowski & Gash (1994, p. 178) describe this task as achieving technological frame congruence:

> *A technological frame contains "the assumptions, expectations, and knowledge [people] use to understand technology in organizations. This includes not only the nature and role of the technology itself, but the specific conditions, applications, and consequences of that technology in particular contexts."*

For example, in the context of technology development projects in companies, Carlile (2004) distinguishes three types of knowledge boundaries that can hinder collaboration between experts: The incompatibility of codes, routines or protocols (syntactic knowledge boundaries), difficulties in translating meanings to others (semantic knowledge boundaries), and a lack of common interest in transforming each other's knowledge (pragmatic knowledge boundaries) (cf. Rau et al., 2015). Shared frames are then understood as a prerequisite for knowledge integration between experts from different professions and organizations. Barriers to collaborating could be attributed to incongruent frames.

Management scholars such as Håkanson (2010) adopt the concept of epistemic communities from the sociologist Holzner (1972). They argue that once members of the same epistemic community have mastered the shared theories, codes, tools and practices, they can easily collaborate across time and space. These individuals can share their knowledge regardless of the intensity of their interactions. These interactions can be face-to-face or technically mediated through Internet-based communication. Knowledge sharing could also occur

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firms, for example, Carlile (2004) has established a typology of syntactic, semantic and pragmatic boundaries. The author argues that knowledge boundaries refer to differences in lexicon (syntactic), meanings (semantic) and interests (pragmatic) among project partners. Collaboration is disturbed as soon as domain-specific knowledge (e.g. functional units) becomes increasingly complex (in terms of differences, dependencies, novelty) (cf. Carlile, 2002; Carlile & Rebentisch, 2003). In contexts of open innovation, Bengtsson et al. (2017) suggests three other types of boundaries: organizational, knowledge and geographical. The authors ascribe these boundaries to differences among organizational units (organizational boundaries), dissimilarities of knowledge among organizations (knowledge boundaries) and geographical distances among organizations (geographical boundaries). Finally, to advance future research on knowledge integration, Tell (2017) suggests to differentiate five types of boundaries: individual, task-related and domain-related as well as spatial and temporal boundaries.

regardless of geographical proximity, e.g. by contacting each other from a distance or interacting closely. Based on such theory-guided assumptions about collective behavior. management scholars suggest that knowledge boundaries (cognitive frames) must be 'bridged' to implement collaborative innovation.

Scholars of knowledge integration suggest that incongruent frames have direct consequences for the strategic management of knowledge. Knowledge boundaries emerge around groups of experts working on specific tasks. According to the literature, the incompatibility of cognitive frames or "*incongruence of technological frames*", as Orlikowski & Gash (1994, p. 180)[22] put it, could explain unintended outcomes of innovation projects. However, knowledge boundaries do not necessarily hinder collaborative innovation. In the context of technology development, knowledge boundaries can be 'bridged' when agents specialized in different knowledge domains share a common set of knowledge that enables them to better assess each other's domain-specific knowledge and understand their cognitive differences (Carlile, 2004). This also implies that in order to achieve minimal knowledge overlap and secure business objectives, cognitive structures such as language, meanings, motivations or interests can be manipulated.

In summary, in contrast to open innovation, the management of knowledge integration implies a more social science approach to collaborative innovation. It argues that a key goal of collaborative innovation is the management of knowledge integration. Simultaneously, it argues that a barrier to collaborative innovation is incongruent cognitive frameworks across professions and organizations, as specialization accentuates cognitive differences across professions and organizations. This results in knowledge boundaries that can hinder collaborative innovation. From this perspective, a praxis of collaborative innovation then requires establishing knowledge integration processes to 'bridge' specialized knowledge by achieving minimal cognitive overlap between members of different epistemic communities to overcome these barriers.

This book is an analysis of these knowledge barriers. Therefore, the next chapter is a summary of the state of the art in research.

22 "Incongruence implies important differences in expectations, assumptions, or knowledge about some key aspects of the technology. For example, a frame incongruence is apparent when managers expect a technology to transform the way their company does business, but users believe the technology is intended to merely speed up and control their work."

2.2.2 Types of barriers to collaborative innovation and knowledge integration

Before presenting a sociological analysis of institutional barriers, we summarize the types of barriers to knowledge integration at the interorganizational level of collaborative innovation that are most relevant to this analysis.

A first barrier is referred to as a *semantic barrier*. These barriers arise when different actors interpret the same information differently, regardless of the context in which the communication takes place. Recent research emphasizes that collaborative innovation requires a shared understanding of vocabulary, concepts, signs or symbols so that semantic barriers do not lead to misunderstandings, hinder the sharing of knowledge or cause external solutions to be forgotten prematurely (Lyng & Brun, 2020; Wojciechowska-Dzięcielak, 2020; Zasa & Buganza, 2024). In addition, an insufficient understanding of customer needs and market requirements, a lack of clarity about the benefits of cooperation and the distribution of risk between the partners can promote semantic barriers (Ates, 2022). By establishing a common understanding, companies can mitigate the effect of semantic barriers and thus overcome different organizational cultures and practices more easily (Rossoni et al., 2024). Boundary objects such as shared documents, prototypes or models can then facilitate knowledge integration by providing an interpretive framework for interactions to translate information or facilitate joint negotiations (Vuillemot et al., 2021).

Research also highlights *pragmatic barriers* as obstacles to collaborative innovation and knowledge integration. Pragmatic barriers occur when the collaboration partners interpret the context of the collaboration differently and, for example, doubt the relevance or benefits of the collaboration (Bø Lyng & Brun, 2020). This means that they pursue different interests and goals in relation to the common context, as they fear that their own competitive position will otherwise be weakened and therefore focus on asserting their own interests instead of negotiating common goals (Lyng & Brun, 2020; Zasa & Buganza, 2024). Recent studies such as that by Zhang et al. (2019) show that aligning objectives, for example by developing a common strategy and building alliance capability, can overcome pragmatic barriers. Thus, pragmatic barriers highlight differences in the interpretation of the shared context of collaboration.

Third, *legitimacy barriers* refer to the acceptance and credibility of external knowledge within an organization. If one organization does not view another as a legitimate partner, this can reduce the willingness to share knowledge (Bø Lyng & Brun, 2020). Research shows that legitimacy barriers pose a particular challenge because even when semantic and pragmatic issues are resolved, knowledge integration can stall because the new knowledge is not

perceived as credible or is not compatible with prevailing beliefs. These barriers show that organizations may initially be skeptical and doubt the validity of the new knowledge until it has been validated internally due to asymmetrically distributed information, lack of industry standards or the novelty of the technology (Bjornali et al., 2017). In interorganizational collaboration, this barrier, which is characterized by a large institutional distance between partners, is exacerbated, manifesting itself in a lack of trust and recognition of expertise (Lyng & Brun, 2020; Zasa & Buganza, 2024). These barriers make it clear that, especially for established organizations, as Grigoriou & Rothaermel (2016) show, knowledge sharing alone is not enough, but new knowledge must first be made connectable internally. At the same time, the study by Horn et al. (2023) on "relative expertise" points out that tolerance towards the knowledge of others and one's own knowledge boundaries can also be a question of personal attitude. In more recent studies, internal trust specialists are then discussed as translators of external knowledge or the demonstration of quick wins as a way of validating external expertise.

The last barrier to be mentioned here relates to *power-based barriers* to knowledge integration. Such barriers arise where power asymmetries lead to the establishment of interpretive sovereignty, from which the validity of external knowledge can easily be challenged. In this regard, Baumstark (2020) points to specialization as a source of power asymmetries. Engstrand & Enberg (2020) clarify the link to legitimacy barriers and show that power can be used to create legitimacy barriers, as interpretations can be actively constructed (Engstrand & Enberg, 2020). In the context of interorganizational cooperation, larger firms can then dictate the terms of collaboration to smaller firms, so that the knowledge of the smaller partner is lost. Recent studies confirm this: Egalitarian forms of collaboration strengthen knowledge integration, while power asymmetries are problematic. Venkataramani and Tang (2023) show that teams within organizations are more likely to benefit from external knowledge if their internal network is more decentralized and no team member monopolizes problem solving. Opening one's own innovation routines to external knowledge, higher incentives for external knowledge collaboration, and systematic knowledge management are then approaches to overcome power-related knowledge barriers (de Faria et al., 2020). Thus, this research shows the influence of the power of collaboration partners as both facilitator or barrier to knowledge integration. This means that legitimacy barriers can be strengthened or weakened by power, which is flexible and negotiable, as shown by Collien (2021) using the example of boundary spanning.

Table 3 summarizes the knowledge barriers relevant to this study that come into play in inter-organizational collaboration and innovation processes.

Table 3: Barriers to collaborative innovation

Barriers	**Institutional aspects**
1) Semantic barriers	Differences in interpretation of information, regardless of the context of the collaboration
2) Pragmatic barriers	Differences in the interpretation of the goals and benefits of collaboration
3) Legitimacy barriers	Differences in the credibility given by the organizations to external knowledge
4) Power-based barriers	Differences in interpretive sovereignty which is constantly negotiated

As will be explained in more detail below, knowledge integration is particularly important in the context of collaborative innovation and the introduction of technologies that are new to a sector. In these contexts, new collaborations need to be established, and firms typically face unusual problems that they cannot solve by relying on existing competencies and partners and replicating what they already know. Instead, companies need to establish collaborations with new, unfamiliar partners.