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A R T I C L E S

IMPLICATIONS OF OPEN INNOVATION FOR ORGANIZATIONAL BOUNDARIES AND THE GOVERNANCE OF CONTRACTUAL RELATIONS

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To create value in an open innovation context, firms need to increase the permeability of their organizational boundaries to enable knowledge exchange with a broad set of partners. Yet to capture value, firms also need to consider how to govern their cooperative efforts and prevent unintended knowledge leakage. This paper develops a novel framework for researching this paradox of openness, which combines an organizational boundary with a relational contract design perspective. First, we extend prior literature by arguing that value is not created only by optimizing resource bundles through external search processes (i.e., competence boundaries). Instead, value can be created by managing interdependencies with external parties (i.e., power boundaries), aligning open innovation activities with the organization's identity (i.e., identity boundaries), and coordinating diverse transactions in an open innovation portfolio (i.e., efficiency boundaries). Second, we propose that relational contract design is an important alternative to formal appropriation regimes and discuss how contractual mechanisms derived from a relational perspective can enable value capture in an open innovation context. Finally, we discuss how firms can strategically manage configurations of firm boundaries and contract design via a set of dynamic capabilities.

In recent years, open innovation (OI) practices have been increasingly adopted and diffused across a variety of organizational and industrial contexts (e.g., Cheng & Huizingh, 2014; Chesbrough, 2003; Gianiodis, Ettl, & Urbina, 2014). Many organizations are currently experimenting with the shift from closed to open innovation. Closed innovation refers to a traditional approach in which new product and process development and related appropriation strategies are primarily confined to the boundaries of the firm. OI denotes a more distributed innovation

process based on purposively managed knowledge flows across organizational boundaries (Chesbrough, Vanhaverbeke, & West, 2006).

Given this development, a pressing concern for firms is to tackle “the paradox of openness” by managing tensions between value creation and value capture (Laursen & Salter, 2014; Wadhwa, Bodas Freitas, & Sarkar, 2017; Wang, Libears, & Park, 2017). To create value, firms need to open their boundaries and enable knowledge exchange with a broad set of partners. Yet to capture value, firms also need to consider how to govern their cooperative efforts and thereby prevent unintended knowledge leakage and protect their critical assets (Pisano & Teece, 2007; Somaya, 2012; Teece, 1986). Paradoxically, the mechanisms firms use to prevent knowledge leakage are likely to impede the processes through

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which external knowledge is identified, exchanged, and combined (Wadhwa et al., 2017).

So far, the OI literature has investigated value creation in terms of firms' external search processes, which result in increased knowledge flows (inbound and outbound) between the firm and a variety of partners and thereby enable novel combinations of knowledge (Chen, Chen, & Vanhaverbeke, 2011; Garriga et al., 2013; Laursen & Salter, 2006; Randhawa, Wilden, & Hohberger, 2016). However, external search openness is a necessary, albeit insufficient, condition for creating value from OI. Transaction costs (Christensen, Olesen, & Kjær, 2005), knowledge integration challenges (Zobel, 2017), and behavioral biases (Antons & Piller, 2015) inhibit value creation from external search openness.

Value capture has been investigated primarily through the lens of appropriability, whereby formal and informal intellectual property (IP) mechanisms allow firms to appropriate value from OI. Yet prior studies have delivered mixed and often conflicting views on the relationship between search openness and appropriation, suggesting positive (Zobel, Balsmeier, & Chesbrough, 2016), negative (von Hippel, 2005), or curvilinear associations (Hagedoorn & Zobel, 2015; Laursen & Salter, 2014; Zobel, Lokshin, & Hagedoorn, 2017). Appropriability regimes that are too strong may inhibit openness and knowledge exchange in the first place (Laursen & Salter, 2014) and thereby increase tensions between value creation and capture. Indeed, Wadhwa et al. (2017) showed that firms' efforts to create value through extramural research and development (R&D) are restrained by the organizational mechanisms they use to protect value. As a result, it remains unclear exactly how firms create value from openness, how they capture value from their OI activities, and how they reconcile tensions between value creation and capture.

In this paper, we digress from the conventional considerations of value creation and capture in terms of search openness and IP. We propose a novel approach to understanding the paradox of openness, which combines an organizational boundary with a contract design perspective. In a first step, we adopt a multidimensional perspective on firm boundaries and discuss OI in terms of the permeability of firms' competence, efficiency, identity, and power boundaries (see Santos & Eisenhardt, 2005). This analysis suggests that firms can be open on different dimensions and expands our current understanding of OI as dominated by external search openness. It further facilitates connecting the phenomenon of OI to existing bodies of organization, management, and strategy theories, thus

building the foundation for a future research agenda. By putting forth this perspective, we argue that value is not created only by optimizing resource bundles through external search processes (i.e., competence boundaries). Instead, value can also be created by managing diverse transactions incorporated in an OI portfolio (i.e., efficiency boundaries), aligning OI activities with the organization's identity (i.e., identity boundaries), and managing critical interdependencies with external partners (i.e., power boundaries).

In a second step, we argue that changes in firm boundaries are associated with how firms govern their contractual relationships with other organizations. In particular, we propose that a relational perspective of contract design becomes increasingly relevant as firms progressively organize more dispersed sources of innovation across permeable firm boundaries (de Figueiredo & Silverman, 2017). Relational contract design is an important alternative to strictly formal and strong appropriation regimes (e.g., through formal IP rights and complete contracts) and has clear implications for how firms capture value from their interorganizational relationships. While strong and formal appropriation regimes may inhibit OI and value creation, relational contracting, characterized by more informal agreements based on flexibility and trust, aligns well with the nature of OI.

Third, we explore how a joint consideration of permeable boundaries and relational contract design helps to reconcile tensions between value creation and capture. Drawing from a dynamic capabilities perspective (Teece, 2007; Teece, Pisano, & Shuen, 1997), we propose that firms can strategically manage configurations of interdependent firm boundaries and contract design. More specifically, we argue that value creation and capture can be achieved by a focal firm's capabilities to (1) sense opportunities for configuring permeable boundaries, (2) seize opportunities via relational contract design, and (3) continuously (re)align permeable boundaries and relational contracts. Combining these perspectives, we offer a novel framework for researchers and practitioners to explore value creation and capture in OI.

CONCEPTUAL BACKGROUND

Organizational Boundary Perspective on Open Innovation

The core idea of OI is that firms open up their boundaries into a semipermeable membrane by increasingly using "purposive inflows and outflows of

knowledge to accelerate internal innovation, and expanding the markets for external use of innovation, respectively” (Chesbrough et al., 2006, p. 1). Hence, the trend toward more OI calls into question the traditional perspective on firm boundaries, which suggests solid demarcations between firms and their environments combined with sporadic make-or-buy decisions. The traditional perspective emphasizes the expansion and retraction of boundaries by investigating under which conditions markets for technologies work and when it is more efficient to conduct innovation activities in-house (e.g., Zenger, Felin, & Bigelow, 2011). It focuses on single transactions or on repeated transactions between the same parties (Williamson, 1985, 1991).

We posit that the phenomenon of OI requires a different view that emphasizes the permeability rather than the scope of boundaries. In the context of OI, firms engage in a variety of hybrid governance forms that lie in between hierarchy and markets. For example, firms join meta-organizations that exist independently of the individual firm and in which heterogeneous sets of partners conduct collaborative innovation activities (Gulati, Puranam, & Tushman, 2012). Outsourcing is increasingly complemented by “co-creation” in which it becomes less clear-cut which innovative activities are conducted internally and which are conducted by external parties. Theories that focus on discrete market transactions across firm boundaries fail to explain these new forms of collaborative innovative activities.

While the permeability of boundaries is central to the definition of OI, existing literature has been surprisingly silent on the implications of openness on firm boundaries. The OI literature has primarily adopted a knowledge-based understanding of boundaries whereby external search processes enable inter-organizational knowledge flows. We expand this discussion by building on a more recent multifaceted consideration of firm boundaries (e.g., Gulati et al., 2012; Zenger et al., 2011). Santos and Eisenhardt (2005) put forward the most comprehensive view of organizational boundaries, in which four different boundary types (competence, efficiency, identity, and power) demonstrate distinct features and decision-making criteria. First, competence boundaries are set at the point that maximizes the value of the firm’s resource portfolio. Second, efficiency boundaries are set at the point that minimizes the cost of governing activities either inside the firm or via external exchanges. Third, identity boundaries are set to achieve coherence between the identity of the organization and its activities. Fourth, power boundaries are set at the

point that maximizes strategic control over crucial external forces. These boundary types are interdependent and may display complementary, substitutive, or coevolutionary relationships (Santos & Eisenhardt, 2005).

We argue that this multidimensional boundary perspective can fuel a deeper understanding of the phenomenon of OI. In particular, understanding the permeability (rather than the scope) of these boundary types will shed light on how firms organize for OI and which types of mechanisms transform boundaries into semipermeable membranes. First, we argue that competence boundaries, which deal with the kinds of resources a firm should possess, are at the core of OI. In line with prior literature that has adopted a primarily knowledge-based understanding of OI, this boundary perspective helps identify the mechanisms that facilitate the flow of knowledge resources into and outside of the organization. Second, efficiency boundaries deal with reducing the costs of these knowledge flows by minimizing transaction and coordination costs. We argue that the efficiency perspective helps us understand how, in an OI context, firms shift from considering atomistic make-or-buy decisions to managing broader portfolios of heterogeneous transaction and governance modes. Arguably, competence and efficiency boundary considerations play a role in any degree and type of OI activities, ranging from atomistic outsourcing decisions to more complex co-creation processes in meta-organizational settings. More specifically, any type of external and/or collaborative innovative activities will involve the interorganizational transfer of resources (i.e., increasing the permeability of competence boundaries), which is enabled by specific governance modes (i.e., increasing the permeability of efficiency boundaries).

While these two boundary types are at the core of OI, we highlight the importance of complementing them with identity and power perspectives on organizational boundaries. In particular, the more a focal firm engages in a greater degree and variety of OI activities, the higher the likelihood that there will be implications in terms of identity and power. Identity boundaries maintain coherence of the organization by aligning organizational activities with its organizational identity (Santos & Eisenhardt, 2005). As employees gradually become more involved in activities outside the boundaries of the firm, they may begin to identify with their external partners, which has implications for their identification with their home organization (Bogers et al., 2017). As such, an identity perspective on organizational boundaries

may move OI research toward a more refined understanding of the process by which organizations become more open or closed.

Power boundaries focus on how organizations control their broader set of exchange relations (Santos & Eisenhardt, 2005). Such power considerations are likely to become more important the more OI activities move into the center of the firm's strategic decision making. For example, focal firms that do not produce independent product offerings but navigate entire platforms or innovation ecosystems may use OI strategically to shape the activities and behaviors of actors that offer complementary products, services, and technologies. In such settings, OI has important implications for power boundaries that aim at expanding the focal firm's sphere of influence. We identify the understanding of permeable identity and power boundaries as important research gaps in the literature and develop suggestions for how future research on the permeability of these boundary types can lead to a better understanding of OI.

Contractual Perspective on Open Innovation

The permeability of firm boundaries has implications for how parties can capture value via the governance of their joint innovation activities. When firms decide how to organize innovation activities across boundaries, they also need to define contractual forms of governance, no matter how formal or informal they turn out to be (Zenger et al., 2011). We posit that the role of firm boundaries and governance of innovation activities is reflected in a transition from a classical to a neoclassical and increasingly relational contracting perspective—that is, from discrete, formal, and short-lived contracts to more open-ended contracts and more informal arrangements. As the clear boundaries between parties that would otherwise engage in discrete transactions become porous, contracts shift from more or less complete, one-off, written agreements (Williamson, 1986) toward more long-term interactive relationships (de Figueiredo & Silverman, 2017; Hagedoorn & Heslen, 2007) in which a broader set of norms guides the behavior of firms (Macaulay, 1963; Macneil, 1978).

This relational contract design perspective gains increasing relevance in the context of OI as firms organize a range of external sources of innovation across their permeable boundaries. As such, relational contract design is an important alternative to strictly formal contract design that comes with strong appropriation regimes through formal IP rights and

attempts to formalize complete contracts in a closed innovation environment.

OPEN INNOVATION IN TERMS OF PERMEABLE FIRM BOUNDARIES

To understand the implications of OI for different boundary types, we conducted a systematic literature search via Web of Science. Following West and Bogers (2014), we limited our search to the top 25 innovation management journals.¹ We classified the identified papers into four categories: (1) competence boundaries, (2) efficiency boundaries, (3) identity boundaries, and (4) power boundaries. In a first step, we used a list of keywords to arrive at an initial categorization (see Table 1). In a second step, we read the abstracts to determine the extent to which the articles deal with different boundary types (e.g., the keyword *competence* may be used in a very generic sense). In a third step, we carefully read the full articles to understand their implications for the permeability of boundary types. Out of 228 articles that treat OI as a central construct, about one third (77) have implications for the permeability of organizational boundaries. As expected, the most populated category examines competence boundaries (37 articles), focusing on how OI enables the transfer of resources across firm boundaries and pointing out organizational competencies required to do so. Also

¹ *Academy of Management Journal, Academy of Management Review, Administrative Science Quarterly, American Economic Review, California Management Review, Economic Journal, Harvard Business Review, IEEE Transactions on Engineering Management, Industrial and Corporate Change, International Journal of Technology Management, Journal of Marketing, Journal of Marketing Research, Journal of Political Economy, Journal of Product Innovation Management, Long Range Planning, Management Science, MIS Quarterly, MIT Sloan Management Review, Organization Science, R&D Management, Research Policy, Research-Technology Management, Strategic Management Journal, Technological Forecasting and Social Change, and Technovation.* We searched for "open innovation" in the title, abstract, or keywords. We further limited the search to publications in 2003 and later years (i.e., following Chesbrough's seminal contribution in 2003), resulting in 386 articles. Subsequently, we followed Lane, Koka, and Pathak's (2006) approach to classify these articles as either focused or non-focused according to the centrality of OI to the paper's core topic. We excluded articles that used the term OI in the context of user innovation, open source, open standard setting, open science, or university–industry relations. This reduced the number of articles to 228.

TABLE 1
Permeability Mechanisms and Contract Design Elements of Organizational Boundaries

Boundary type	Definition	Keywords	Permeability mechanisms	Contract design elements
Competence	The (knowledge) resources and competencies that the firm owns or coordinates	Resource access, resource transfer, capabilities, capacity, competencies, knowledge orchestration	<ul style="list-style-type: none"> - Strategic balance between internal and external R&D - Organizational procedures, processes, and tools that enhance absorptive capacity - Network-level knowledge development and sharing - Individual-level competencies for knowledge transfer - Descriptive capacity for external commercialization - Unsolicited knowledge flows 	<ul style="list-style-type: none"> - Resource access through reciprocity and mutuality - Sharing of absorptive capacities
Efficiency	The governance of activities within and outside the firm; concerns ownership, control, and transaction costs	Ownership, transaction cost, intellectual property, governance	<ul style="list-style-type: none"> - Increased variety and dynamic adjustment of governance forms - Informal coordination mechanisms (e.g., selective revealing) - Proactive IP management (e.g., IP modularity) - Balanced appropriability regime - Strategic selection of formal and informal IP 	<ul style="list-style-type: none"> - Contractual flexibility - Open-ended contracts and renegotiation options - Bilateral dependence with coordination and communication - Nonexclusive and jointly allocated IP
Identity	The informal organization that is shaped by social identification	Identity, cognition, framing, culture, incentives	<ul style="list-style-type: none"> - New attitudes to (external) knowledge - Social integration (across firm boundaries) 	<ul style="list-style-type: none"> - Transparency and openness toward partners - Partner orientation and adaptability - Flexible mindsets - Risk sharing rather than risk allocation - Trusted relationships, shared identity, solidarity
Power	Power issues and the degree of authority and influence the firm can exercise	Power, authority, dependence, dependency, control	<ul style="list-style-type: none"> - Relinquishing decision-making rights - Power via selective revealing 	<ul style="list-style-type: none"> - Cooperative social norms as informal safeguards - Shared decision making - Joint problem solving and conflict resolution - Amicable terms of termination

in line with our expectations, the second largest category refers to efficiency boundaries (30 articles) that deal with the governance of OI activities. Substantially less populated are the categories dealing with identity (6 articles) and power boundaries (4 articles).

To analyze the contract design of relationships across these different types of permeable boundaries,

we used a similar procedure. Given the little empirical work done on contracting and interorganizational collaboration in general (see Gil & Zanarone, 2017; Schepker, Oh, Martynov, & Poppo, 2014), we extended our search to a combination of two groups of keywords: (1) *OI, alliances, cooperation* and (2) *contracts, contract(ual) design, classical contracting, neo-classical contracting, relational contracting*. We

also extended the search to papers published after 1990, when the growth in papers on interorganizational cooperation led to a modest increase in attention to contract design. Various combinations of keywords produced a small body of literature (22 articles).

In the following, we offer an analysis of how existing OI literature can be viewed through the perspectives of permeable boundaries and relational contract design. More important, we discuss how this perspective lays the foundation for a future research agenda on value creation and capture in an OI context. Table 1 displays the results of this analysis, including mechanisms of boundary permeability and design elements of relational contracts.

Permeability of Competence Boundaries

How does engagement in OI transform a focal firm's competence boundaries and thereby modify the resource portfolio that it coordinates? Somewhat counterintuitively, one condition for more permeable competence boundaries is continued investment into the internal production of knowledge resources. Due to enhanced absorptive capacity, firms with greater internal R&D are more likely to collaborate with external partners (Tether & Tajar, 2008; Xia, 2013) and to benefit more from them (Chen, Vanhaverbeke, & Du, 2016; Denicolai, Ramirez, & Tidd, 2016; Garcia Martinez, Zouaghi, & Sanchez Garcia, 2017). However, research is inconclusive as to the level of internal R&D at which internal and external R&D activities are complementary or substitutive (Berchicci, 2013; Hagedoorn & Wang, 2012). Similarly, internal R&D has been found to be complementary to certain types of external partners (e.g., value chain partners), while it is less relevant for other OI partnerships (e.g., collaborations with universities) (Chen et al., 2016). Furthermore, while internal R&D combines negative short-term with positive long-term implications for the accumulation of knowledge, external R&D has immediate positive effects but is less efficient in the long term (Denicolai et al., 2016). Jointly, these insights suggest that firms that are active in OI strike a strategic balance between internal and external knowledge.

A number of organizational procedures, such as the formal organization of R&D (Bianchi, Croce, Dell'Era, Di Benedetto, & Frattini, 2016) and knowledge governance procedures (Lakemond, Bengtsson, Laursen, & Tell, 2016), enable firms to leverage external knowledge resources. Such absorptive capabilities further enhance the permeability of competence

boundaries by enabling the recognition, integration, and conversion of external knowledge resources (Robertson, Casali, & Jacobson, 2012; Zobel, 2017). Absorptive capacity is further supported by a set of information and communication technology (ICT) tools, such as technology scouting techniques, data mining, data access systems, and network connectivity (Porter & Newman, 2011; Rohrbeck, 2010; Spitsberg, Brahmandam, Verti, & Coulston, 2013; Trantopoulos, von Krogh, Wallin, & Woerter, 2017; Veugelers, Bury, & Viaene, 2010), that enable firms to increase their internal and external communication and access to related resources. However, while ICT investment enables access to a wider scope of external knowledge resources, excessive ICT can cause information overload and thereby limit a focal firm's ability to source knowledge resources across firm boundaries (Dong & Netten, 2017). Individual-level competencies, such as boundary spanning (du Chatenier, Verstegen, Biemans, Mulder, & Omta, 2010; Ollila & Yström, 2017; Whelan, Parise, De Valk, & Aalbers, 2011), entrepreneurial orientation (Ahn, Minshall, & Mortara, 2017), educational diversity (Bogers, Foss, & Lyngsie, 2018), and technological expertise and open-mindedness (Pedrosa, Välling, & Boyd, 2013), constitute the microfoundations of absorptive capacity (Ter Wal, Criscuolo, & Salter, 2017).

In an OI context, knowledge absorption activities are not confined to the firm level. Instead, firms can develop absorptive capacity by teaming up with third parties that perform knowledge intelligence, assimilation, and transformation activities (Kokshagina, Masson, & Bories, 2017; Spithoven, Clarysse, & Knockaert, 2011). Similarly, firms organized in networks collectively engage in knowledge absorption activities (Chen, Zhao, & Wang, 2014; Heger & Boman, 2015; Müller-Seitz, 2012). Shared intellectual capital can expand to "knowledge commons" at the level of the network organization. As such, firms expand their competence boundaries to the network level as they collectively share, develop, and maintain knowledge resources (Snow, Fjeldstad, Lettl, & Miles, 2011).

Due to the dual nature of OI in terms of inbound and outbound flows, a firm's "desorptive" capacity constitutes an additional mechanism for increasing the permeability of competence boundaries. Desorptive capacity refers to the capabilities for externally commercializing knowledge (Bianchi, Chiesa, & Frattini, 2011). Similar to its absorptive counterpart, desorptive capacity is developed via task-specific experience (e.g., out-licensing experience) and supported by human capital, marketing,

and relational capabilities (Bianchi, Frattini, Lejarraga, & Di Minin, 2014; Bianchi & Lejarraga, 2016). Synergies between these two capacities further increase permeability, given that inbound OI (supported by absorptive capacity) and outbound OI (supported by desorptive capacity) reinforce each other (Sikimic, Chiesa, Frattini, & Scalera, 2016).

OI also enables new types of resource flows that further penetrate competence boundaries. For instance, firms can benefit from unsolicited external contributions, which refer to noncontractual and voluntary submissions of innovation-related knowledge from external sources (Alexy, Criscuolo, & Salter, 2012). Firms can systematically entice individuals and organizations to create knowledge outside a firm's boundaries and proactively push it into the firm's innovation projects (Dahlander & Piezunka, 2014; Spaeth, Stuermer, & von Krogh, 2010).

In sum, OI literature considerably informs our understanding of the competence boundaries of firms and allows us to identify mechanisms that reflect increased permeability of these boundaries (as summarized in Table 1). An interesting avenue for future research is to examine these mechanisms at different levels of analysis. On one hand, OI research at the network level is still relatively scarce (Bogers et al., 2017). How do networks of firms manage their joint resource portfolio? How do they design the intersection between the individual firm's resources and the resource portfolio of the network organization? Studying the usage of knowledge commons and knowledge-sharing procedures could shed light on these questions (see also Fjeldstad, Snow, Miles, & Lettl, 2012). On the other hand, research on micro-foundations of resource absorption and desorption can help delineate how and why individuals differ in their competencies to identify, assimilate, and utilize external knowledge resources. Finally, future research needs to develop a deeper understanding of the dynamic capabilities that continuously modify a focal firm's resource base via outside-in and inside-out knowledge flows in an OI setting (e.g., Teece, 2007).

Permeability of Efficiency Boundaries

As knowledge resources are transferred across more permeable competence boundaries, a closely related boundary consideration refers to the appropriate governance choices for realizing such resource transfers. The OI literature reveals a large variety of governance forms that are positioned in between hierarchies and markets. Traditional

inbound modes include in-licensing, equity investments, acquisitions, joint ventures, R&D contracts, purchase of technical services, and alliances (Bianchi, Cavaliere, Chiaroni, Frattini, & Chiesa, 2011). Outbound governance modes encompass out-licensing, spinouts, sales of innovation projects, joint ventures for technology commercialization, supply of technical services, corporate venturing investments, and alliances (Bianchi, Cavaliere, et al., 2011). These governance modes are characterized by an increasing diversity of partners, including suppliers, customers, competitors, consultants, R&D institutes, universities, intermediaries, communities, and individual inventors. This partner diversity enables new forms of governance, such as crowd-sourcing (Afuah & Tucci, 2012).

As firms shift to an increasing variety of governance modes, they also introduce more flexibility into the management of such a portfolio. Firms engaged in OI dynamically adjust governance modes along different phases of the R&D process (Bianchi, Cavaliere, et al., 2011) and along maturity levels of the technology regime (Christensen et al., 2005). Attributes of individual innovation problems, rather than more general transaction characteristics, determine firms' choices in terms of which forms of governance are most efficient and when to shift across different forms (Felin & Zenger, 2014). This may lead to OI activities that are conducted under conditions of high transaction costs (Christensen et al., 2005).

In case traditional governance modes fail or are too costly, alternative coordination mechanisms such as relational trust, partnership reputation, and interfirm socialization can facilitate interactions (Christensen et al., 2005; Gesing, Antons, Piening, Rese, & Salge, 2015). Firms may even freely reveal their proprietary knowledge and give all external parties equal access to it (von Hippel & von Krogh, 2006) or reveal it selectively (Alexy, George, & Salter, 2013). In addition, firms engaged in OI introduce novel coordination and incentive mechanisms, such as contest prizes (Felin & Zenger, 2014) or boards specifically designed for OI (Wincent, Anokhin, & Boter, 2009). Together, these mechanisms represent alternatives to traditional forms of coordination and focus increasingly on relational rather than transactional characteristics.

As efficiency boundaries become more permeable, the risk of knowledge leakage increases as well (Frishammar, Ericsson, & Patel, 2015; Veer, Lorenz, & Blind, 2016). This requires the institutionalization of new IP practices (Munsch, 2009), such as allocating

IP rights (Mehlman et al., 2010), dividing IP across separate modules of a product's system architecture (Henkel, Baldwin, & Shih, 2013), bundling different IP mechanisms in different phases of the innovation process (Manzini & Lazzarotti, 2016), compartmentalizing IP in the context of multiparty collaborations (Leten, Vanhaverbeke, Roijackers, Clerix, & Van Helleputte, 2013), or disassembling IP at the termination of an OI project (Granstrand & Holgersson, 2014). IP is not exclusively used as an isolating mechanism, but rather facilitates the disclosure, transfer, and structuring of innovation-related knowledge (Hagedoorn & Zobel, 2015; Hurmelinna, Kyläheiko, & Jauhiainen, 2007) or attracts potential partners for future projects (Alexy, Criscuolo, & Salter, 2009).

In general, there seems to be a consensus in the literature that a firm's openness in innovation is curvilinearly related to its appropriation strategy (Huang, Rice, Galvin, & Martin, 2014; Laursen & Salter, 2014; Miozzo, Desyllas, Lee, & Miles, 2016; Stefan & Bengtsson, 2016; Zobel et al., 2017). Thus, interestingly, permeable efficiency boundaries do not equate to a looser appropriation regime. On the contrary, to some extent tighter appropriation strategies enable more permeable efficiency boundaries as they facilitate the transfer of knowledge (Zobel et al., 2016). Modest levels of emphasis on appropriability mechanisms prevent knowledge leakage and conflicts over ownership of jointly developed assets, while also avoiding possible negative effects of overly strict controls by legal departments (Miozzo et al., 2016). At some point, however, tight IP strategies act as a barrier to knowledge exchange, whereby aggressive enforcement of IP rights comes at the cost of foreclosing the diffusion of knowledge across partners (Bhaskarabhatla & Hegde, 2014). Wadhwa et al. (2017) found that isolating mechanisms such as employee retention and secrecy reduce value creation from OI. Firms can use a variety of both formal (patents, trademarks, copyrights, design rights) and informal (secrecy, lead time, process/product complexity, employee retention) appropriation mechanisms in interactions with their partners (Arora, Athreye, & Huang, 2016; Hagedoorn & Zobel, 2015; Huang et al., 2014; Wadhwa et al., 2017). Formal and informal mechanisms are selectively employed across openness dimensions (breadth vs. depth of collaborations) (Zobel et al., 2017) and across national versus international partners (Stefan & Bengtsson, 2016).

In sum, existing OI research contributes substantially to a discussion of efficiency boundaries. Taking stock of existing literature, we identified five

concrete mechanisms that facilitate permeable efficiency boundaries in the context of OI (see Table 1). Nevertheless, the efficiency perspective of OI provides several opportunities for future research. For instance, future research can further explore the combination of traditional governance forms that make use of hierarchical coordination mechanisms (e.g., licensing or joint ventures) and new forms of governance that rely more on informal mechanisms (e.g. selective revealing). Such a governance portfolio perspective would shed light on how firms achieve semipermeable efficiency boundaries and explain which combinations of governance modes maximize the benefits derived from external sources of innovation. Further pursuing this research avenue, future studies can address how firms manage their heterogeneous governance portfolio over time and under which conditions they adapt the balance between formal and informal modes.

Permeability of Identity Boundaries

As firms increasingly engage in OI activities, the permeability of firm boundaries extends from competence (i.e., which kinds of resources to coordinate) and efficiency (i.e., how to govern resource transfer) considerations to affecting the entire identity of the organization. The identity boundary perspective deals with the unconscious boundaries of the mind (Santos & Eisenhardt, 2005). This is relevant in an OI context, as the transition from closed to more open innovation requires a shift in mindset and cognitive frames. Individual-level mindsets anchored in a closed-innovation world, such as the not-invented-here (NIH) and not-shared-here (NSH) syndromes (Burcharth, Knudsen, & Søndergaard, 2014; Herzog & Leker, 2010), inhibit inbound and outbound OI, respectively. New coping strategies (Salter, Criscuolo, & Ter Wal, 2014), human resource management practices (Burcharth et al., 2014), leadership processes (Ollila & Yström, 2017), and incentive mechanisms (Fu, 2012; Salter et al., 2014) are potential solutions for overcoming attitudes associated with closed innovation. These mechanisms aim at modifying attitudes to knowledge, such that employees are no longer biased toward internal paths to knowledge creation and commercialization, but consider external paths as equally viable alternatives.

A further mechanism indicative of permeable identity boundaries refers to the process of social integration. People from different organizations are likely to draw from different frames of reference and typically operate in unique social contexts. As a

result, mechanisms of social integration play an important role in facilitating the integration of knowledge from different partners (Dingler & Enkel, 2016). For example, management can engage in sensegiving activities such that all collaboration partners share some common understanding (Ollila & Yström, 2017). Alternatively, employees can temporarily leave their own organization to become immersed in partner firms (Salter et al., 2014). Socialization is developed through shared social experiences, joint activities, personal interaction, and physical proximity (Dingler & Enkel, 2016). These mechanisms help to create a new distinct identity for the parties involved in the collaboration, one that exists independently from any partner's social context.

In sum, our analysis of the OI literature suggests that new attitudes to (external) knowledge and social integration mechanisms enable permeable identity boundaries (see Table 1, above). We believe that future research can further develop this perspective by building on and expanding the theory of organizational identity and/or identification. As firms engage in projects with a variety of external partners that unite for the pursuit of common objectives, they are likely to create multiple collective identities that match specific situations and partner types. It will be interesting to study to what extent these new identities are contextual (Pratt & Foreman, 2000) and triggered by situational cues and relevant settings (Ashfort & Mael, 1989).

What kinds of processes do firms need to implement to manage the multiple identities required to deal with conflicting demands of a variety of OI partners? Theory on organizational identification can inform research on how employees identify with multi-identity organizations in an OI setting (see, e.g., Foreman & Whetten, 2002). Future studies can further examine how collective identity helps individual participants in the collaboration attach importance to an issue, collectively invest time and energy in it, commit to any compromises involved in tackling it, take collective risks, and secure support from their respective organizations (e.g., Hardy, Lawrence, & Grant, 2005). It will be important to study the extent to which collective identities are stable versus unstable over time.

Permeability of Power Boundaries

As OI moves into the center of a focal firm's strategic decision making, it will not only affect its competence, efficiency, and identity boundaries but will also have implications for the firm's power

boundaries, which deal with strategic control over external entities. So far, only two conceptual studies have dealt with the permeability of power boundaries in terms of control, dependence, and authority. Gambardella and Panico (2014) examined the allocation of decision-making rights in collaborative settings. The authors showed via a formal model that, in an OI setting, firms may relinquish decision-making rights to another party to compensate for the lack of incentive to collaborate and to offset a potential partner's weaker bargaining power. Alexy et al. (2013) conceptualized "selective revealing" as a mechanism for exercising power and discussed how selective revealing can deliberately shape the collaborative behavior of partners. Problem and solution revealing can be used to induce other actors to become more similar to the focal firm—a mechanism referred to as "induced isomorphism," which is a subtle form of manipulation and represents an exercise of power over external parties. Apart from these two contributions, only a small number of studies touch tangentially on power boundaries by discussing strategies and processes for managing power imbalances in the context of asymmetric relationships (Mehlman et al., 2010; Minshall, Mortara, Valli, & Probert, 2010).

Thus, existing OI literature has not extensively discussed the permeability of power boundaries (see Table 1, above, for a summary). This leaves a wide gap for future research, given that the context of OI suits itself well to studying interdependencies between firms, particularly those that go beyond dyadic interdependencies that typically characterize supplier–buyer relationships or other types of alliances. The literature on innovation ecosystems (e.g., Adner, 2017), for example, studies complex patterns of interdependencies among a wide range of actors that produce complementary products and services. Such multilateral interdependencies can no longer be exclusively managed via ownership mechanisms but increasingly rely on collaborative strategies. This opens up a number of interesting questions that can be studied from the perspective of OI and permeable power boundaries: How can multiple interdependent firms allocate decision rights and achieve joint decision making? To what extent and how are firms exercising power over their ecosystem partners? Are there any informal means to shape the behavior of partners beyond the use of strategic revealing? To what extent do firms need to let go of some control to maintain the overall functioning of their innovation ecosystem? Future research on power boundaries can progressively extend beyond the level of the firm

and its legal entities to a wider innovation ecosystem, whereby the focal firm enlarges its sphere of influence and attempts to influence and shape other firms' innovative activities.

GOVERNING PERMEABLE BOUNDARIES THROUGH CONTRACT DESIGN

This section develops a better understanding of how the OI-led mechanisms of increased permeability of boundaries are associated with the design of interorganizational contracts. Our analysis will demonstrate that increasing permeability of boundaries requires a change from a classical to a more relational contracting perspective (see Table 1, above).

Contract Design of Permeable Competence Boundaries

Smith and King (2009) indicated that interorganizational contracts are applied to secure firms' competencies and their underlying knowledge resources, and to capture future rents. In a setting that we would characterize as neoclassical contracting with a limited relational perspective, firms may draft "contracts that make resource distributions to the firm more ambiguous and therefore more difficult to replicate. Contracts may omit certain details in the interest of preventing firm-specific resources from escaping and spreading" (Smith & King, 2009, p. 28). However, as firms engage in relationships where the joint innovative activities of parties and knowledge sharing become crucial for the development of network-level absorptive capacity, the nature of their contract design changes. The more open-ended contracts become and the more sharing of competencies is critical to firms' cooperation with their partners, the more Macneil's relational norms in terms of reciprocity and mutuality demand trust between partners for governing the actual contractual relationship (Hatten, James, Fink, & Keeler, 2012; Macneil, 1978).

When firms engage in in-depth cooperation and share, transform, and further develop knowledge with partners, partly open-ended, flexible, and hence incomplete contracts are unavoidable as it is impossible to specify all future contingencies related to knowledge development and sharing (Parkhe, 1993). In essence, such contracts are neoclassical in nature if the contract is still largely based on a written document that stipulates a range of provisions, in particular those related to IP rights, adaptation of the contract, damages, and dispute resolution (Hagedoorn

& Heslen, 2007). The more knowledge is shared with other organizations in a trusted relationship, the more this knowledge becomes subject to relational contracting. Through this relational contracting, interorganizational trust is complemented by incomplete contracts with few provisions (Woolthuis, Hildebrand, & Nooteboom, 2005) that act merely as semiformal frameworks for cooperation (Blomqvist, Hurmelinna, & Seppänen, 2005).

This has clear implications for understanding the role of the absorptive capacity of a firm and the sharing of competencies across organizational boundaries. Neoclassical and relational contracting practices offer flexibility—in terms of joint problem solving, coordination, and long-term commitment (Blomqvist et al., 2005; Poppo & Zenger, 2002; Woolthuis et al., 2005; Yeung, Chan, & Chan, 2012)—that enables partners to cooperate in an adequate contractual setting. Such contractual features, together with trust and shared social norms, and the lower relevance of the actual written contract, create a relational perspective on the contract design of interorganizational relationships.

This suggests that the more permeable the competence boundaries of firms through OI, the more their contract design needs to be associated with a transition from a classical to a more relational contracting perspective (see Table 1, above). In this context, interesting questions for future research refer to the specification of resources, the degree of incompleteness of contracts that govern knowledge flows, and the role of written contracts. Contract parties bring specific competencies to joint innovation efforts, and given appropriability concerns, an interesting question is to what extent and under which conditions firms that engage in OI prefer to omit certain details regarding their competencies and related resources from contracts or whether they prefer to contractually specify relevant competencies and resources. With increased permeability of competence boundaries and growing knowledge flows between partners, trust in relational contracting becomes crucial for successful cooperation. However, as contracts can still act as semiformal frameworks, interesting questions remain: What does this semiformal status imply, and what is the nature of provisions that stipulate the competencies and resources that parties are willing to share and develop? These questions ultimately suggest one basic question: If trust becomes so crucial and contracts are increasingly incomplete, flexible, and guided by social norms, to what extent are written contracts still relevant?

Contract Design of Permeable Efficiency Boundaries

As firms increase the permeability of their efficiency boundaries and engage in a larger variety and more dynamic forms of governance, they require contracts that enable them to flexibly coordinate their joint efforts and allow them to deal with unexpected events. Contrary to classical contracting, neoclassical contracting—and even more so relational contracting—enables relationships based on flexibility (Faems, Janssens, Madhok, & van Looy, 2008; Gil, 2009; Todeva & Knoke, 2005; Yeung et al., 2012). The relational nature of this contracting perspective allows for open-ended contracts, in which future developments are left to be decided on as circumstances change and particular contract clauses can be renegotiated or subsequent contracts build on or extend previous contracts (Hagedoorn & Heslen, 2007).

The role of flexible coordination from a neoclassical and relational contracting perspective depends, given the focus on commitment and bilateral dependence, on “behavioral transparency” (Parkhe, 1993, p. 801) that enables partners to share information, to communicate, and to coordinate the progress during their actual cooperation. Writing and designing contracts enables firms to communicate with partners (Smith & King, 2009), and they can also serve as a repository for individual tasks to be undertaken by partners and facilitate the actual coordination and monitoring of these tasks (Argyres & Mayer, 2007; Mellewigt, Madhok, & Weibel, 2007; Reuer & Ariño, 2007). As such, an important element of relational contracting is the increasing degree to which joint problem solving through communication and a strong emphasis on coordination play a role in partner interactions (de Figueiredo & Silverman, 2017; Malhotra & Lumineau, 2011; Todeva & Knoke, 2005; Woolthuis et al., 2005; Yeung et al., 2012).

In addition, proactive IP management in OI calls for more neoclassical and relational contracting. This holds in particular if this cooperation is not based on equity-sharing and both ownership and residual control rights do not automatically account for the division of IP rights among partners (Root, 1988). Hagedoorn and Heslen (2007) found that in nonequity partnerships, contracts with a certain degree of relational contracting stipulate that firms retain IP rights to their original input but share or divide the IP related to jointly developed new technologies. Research by Hagedoorn and Zobel (2015)

on the role of IP rights in OI indicates that these IP rights are used by firms not only as exclusion rights in terms of defensive appropriation mechanisms, but also to selectively reveal knowledge to particular partners and as a more general signal of innovative capabilities (see also Alexy, Criscuolo, & Salter, 2009). Thus, proactive IP management in an OI context is reflected in more relational contract design that allows for a more complex and strategic utilization of IP.

In sum, this suggests that the more permeable the efficiency boundaries of firms, the more this will extend to a relational contracting perspective, as reflected in increased flexibility of the governance of relationships, increased coordination of the cooperation process through contractual means, and increased use of IP rights for knowledge sharing rather than protection. This relational contracting perspective in the context of more permeable efficiency boundaries suggests a number of interesting research questions. As firms increasingly engage in OI, will the need for greater flexibility of the governance of relationships lead to open-ended contracts such that the role of written, legally enforceable documents diminishes? Even if written contracts continue to play a role, will their legal status be subordinate to their function as a repository of tasks that facilitates communication about the coordination and monitoring of the joint innovation process? If formal IP rights are increasingly used for knowledge sharing, will this also affect the role of informal IP (such as secrecy, lead time, and process and product complexity) to the degree that firms engage in knowledge sharing with such a variety and quantity of OI partners that informal IP becomes an interorganizational innovation attribute rather than a firm-specific innovation attribute?

Contract Design of Permeable Identity Boundaries

Increased permeability of identity boundaries through OI is reflected in neoclassical and especially relational contracting, which demand a greater degree of flexibility and transparency and openness toward partners (Parkhe, 1993; Todeva & Knoke, 2005). The more relational the contracting practice of firms becomes, the more they are expected to deal with open-ended elements in their contracts, demonstrate flexibility, and share responsibility in a long-term relationship (Blomqvist et al., 2005; Hatten et al., 2012; Woolthuis et al., 2005; Zaheer & Venkatraman, 1995). As such, firms need flexible mindsets and cognitive frames that enable them to

collaborate with others under contractual conditions in which formal contracts are less important (Gil, 2009). Based on interorganizational trust, contracts are then considered a risk-sharing rather than a risk-allocation mechanism (Hagedoorn & Heslen, 2007). The more relational such contracts become, the more firms are expected to become more partner-oriented and take the interests of their partners into account. As the relevance of formal, clear-cut and unadaptable written contracts decreases and unforeseen contingencies play a larger role in long-term relationships, trust and mutuality in shared coordination and joint problem solving become more important (de Figueiredo & Silverman, 2017; Hatten et al., 2012; Macneil, 1978; Woolthuis et al., 2005; Yeung et al., 2012). These relational components support new attitudes and cognitive frames associated with OI.

Furthermore, relational contracting can facilitate social integration mechanisms that characterize permeable identity boundaries. A perception of belonging is essential to cooperation when firms interact with a number of partners over extended periods of time. Neoclassical and relational contracts are not only instrumental in demanding trust between partners but also reinforce trusted relationships (Blomqvist et al., 2005; de Figueiredo & Silverman, 2017; Poppo & Zenger, 2002; Todeva & Knoke, 2005; Woolthuis et al., 2005). These complex trusted relationships with partly open-ended contracts, as firms cooperate over an extended period of time, are sought in particular when firms jointly search for new technologies, products, and processes (Auster, 1992; Hagedoorn, 2002; Mody, 1993; Rosenkopf & Schilling, 2007). This joint search with a number of trusted partners can lead to a more relational contracting practice in which long-term partnering affects relational norms to the degree that partners become subject to increasing levels of group solidarity and “harmonization of their social matrix” (Hatten et al., 2012, p. 4) that create a collective identity.

In short, the permeability of the identity boundaries of firms that engage in OI is associated with the relational contracting mechanisms that are summarized in Table 1 (above). This indicates some interesting future research on the role of relational norms and trust in contracting that partly overlaps with research questions highlighted in earlier sections. Additional research could focus on how actual contracts can feature as open repositories that provide guidelines for deepening partner orientation and the creation of cognitive frames that support OI. An interesting question for further research in that context

is to what extent the public availability of the content of the actual contracts throughout partner organizations and the perception of those contracts by managers can play a role in creating a collective identity that is expected to be instrumental for OI.

Contract Design of Permeable Power Boundaries

Interestingly, the contract literature suggests a more developed understanding of power, control, and dependence issues than the OI literature. From a neoclassical contracting perspective, the sphere of influence of contract parties is not only based on their competence and resource-based ownership that generates control and discretionary power, it is also affected by the development of cooperative social norms as rules of behavior (Lumineau & Oxley, 2012). These cooperative social norms are instrumental in creating informal safeguards for stable long-term interactions (Blomqvist, Hurmelinna, & Seppänen, 2005; Poppo & Zenger, 2002; Zaheer & Venkatraman, 1995). Social norms become even more important in the context of relational contracting, where formal contracts play a limited role (if any) and where trust between parties is crucial for long-term relationships (Faems et al., 2008; Todeva & Knoke, 2005).

In addition, seen from a neoclassical perspective, the degree of control of individual contract parties becomes subject to shared decision making, rather than using or relinquishing individual decision-making rights, in light of long-term coordination and commitment (Woolthuis et al., 2005). The more limited the relevance of the asymmetric degree of power and control and decision-making rights of individual contract parties based on ownership and the more firms engage in shared decision-making and coordination based on trust, the more relational the contracting perspective of their cooperation (Yeung et al., 2012).

As firms engage in more long-term relationships, contract parties become more interdependent, which is expressed in contract clauses that provide provisions for flexibility through joint problem solving, conflict resolution through internal arbitration (Bonn, 1972), and amicable terms of termination (Andrews, 2010; Gil, 2009; Hatten et al., 2012; Luo, 2002; Macneil, 1978). The more the dependency of contract parties is seen in light of solidarity (expressed in reciprocity and restraint of power) and conflict resolution that includes flexibility beyond actual contract clauses (Blomqvist et al., 2005; Hatten et al., 2012; Parkhe, 1993; Woolthuis et al., 2005), the more relational and

messier their long-term contractual relationships (Macneil, 1978).

This implies that the more permeable firms' power boundaries become through OI, the more this requires a shift in contract design from a classical to a more relational contracting perspective (see Table 1 for concrete mechanisms). For future research, this raises a number of interesting questions. As informal safeguards through cooperative social norms and trust become more relevant in shared decision making in OI projects, what does this shared decision making imply when the level of participation among partners differs and/or changes over time? In OI partnerships with a limited number of parties, informal safeguards are important for governing interactions. With increasing numbers of partners, the complexity of projects and the diversity of participants increase, which raises the question of to what extent informal safeguards can still play a crucial role in shaping the governance of such complex OI projects.

So far, a relational contracting perspective appears most relevant in the context of long-term relationships, but OI covers a wide range of innovation horizons, from short-term to extremely long-term projects, which raises the question of to what extent the relevance of social norms, trust, solidarity, and shared decision-making in OI is subject to the duration and intensity of OI activities. Assuming that in OI partners become more interdependent and the governance of their relationship is characterized by flexibility and joint problem solving and the actual contract design is relational but also messy, what does this messy character of relational contracts imply from a legal perspective? In addition, to what extent can messy relational contracts actually obfuscate (potential) control, dependence, and power imbalances between partners in OI?

A CONCEPTUAL FRAMEWORK OF OPEN INNOVATION: STRATEGICALLY MANAGING PERMEABLE BOUNDARIES AND RELATIONAL CONTRACTING

Based on the above analysis, we argue for viewing OI through the perspective of organizational boundaries and relational contract design. As Figure 1 illustrates, openness in innovation is reflected in increased permeability in competence, efficiency, identity, and power boundaries, which in turn requires a contract design that increasingly incorporates relational (as opposed to classical) design elements. These perspectives enable a novel conceptual framework of OI that

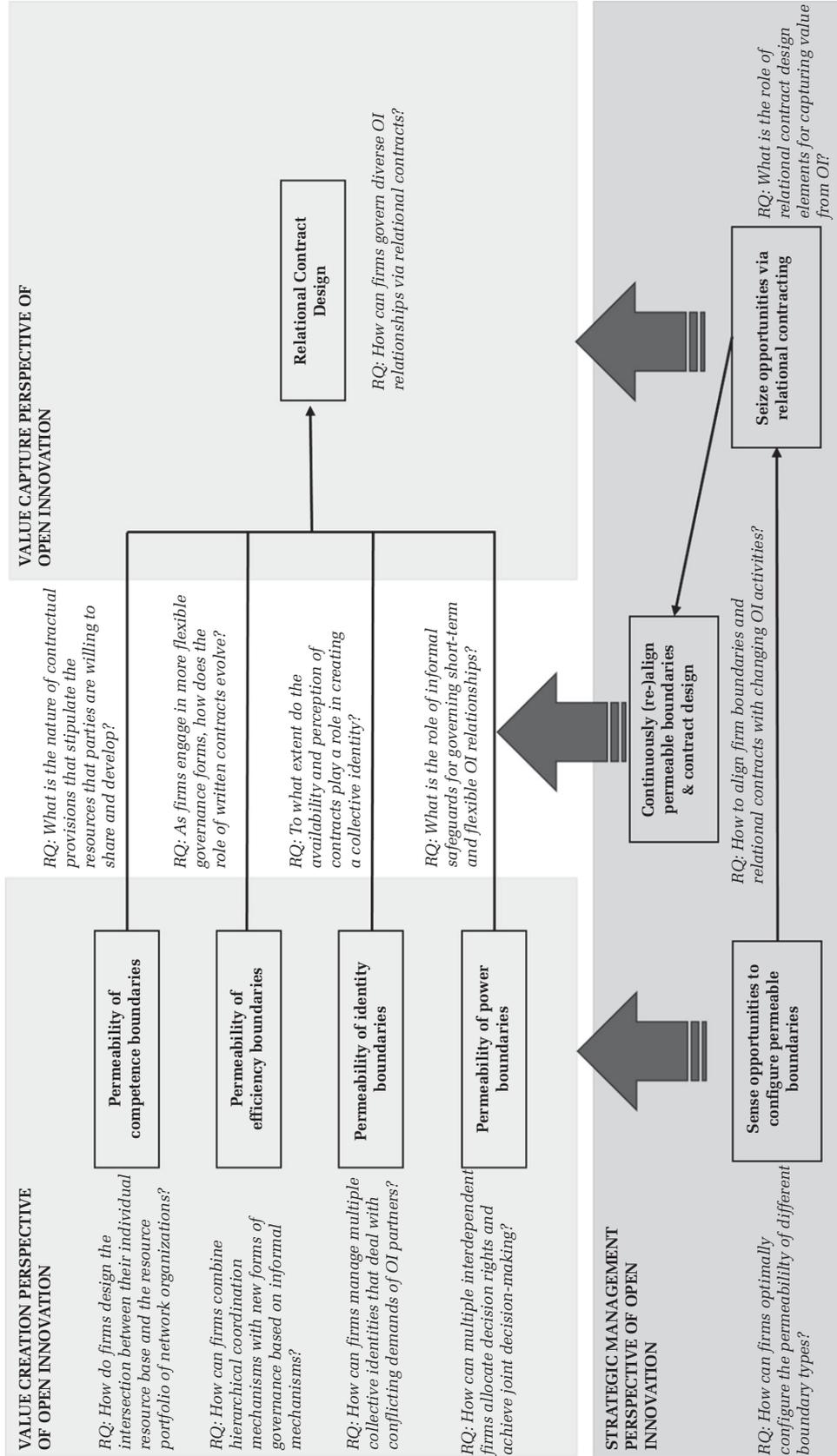
aims to delineate mechanisms of permeable firm boundaries and specify associated changes in contract design with regard to each boundary type. This framework provides a new perspective on value creation (via permeable boundaries) and value capture (via relational contracting) in an OI setting. The upper part of Figure 1 illustrates these perspectives and depicts some exemplary research questions that can shed further light on value creation and capture in an OI context.

First, permeability of competence, efficiency, identity, and power boundaries increase opportunities for value creation in an OI context. In particular, permeable boundaries enable inbound and outbound exchange of knowledge (e.g., via absorptive capacity, multiple forms of governance, shared social identities, and relinquished control) with a broad set of external actors. These exchanges enable firms to combine and recombine a broad range of knowledge options and thereby enhance the potential for value creation (e.g., Ethiraj & Levinthal, 2004).

Second, increased permeability of boundaries can be addressed with a contractual design that increasingly draws from a relational perspective. We propose that relational contracting is a particularly suitable means of value capture across permeable boundaries, as it constitutes a more flexible form of governance based on social norms. Trust, flexibility, transparency, sharing, and reciprocity are not only major elements of these social norms (Faems et al., 2008; Todeva & Knoke, 2005); they also act as informal safeguards that can guide formal and informal appropriation mechanisms collectively applied by partners. Previous research (Hagedoorn & Zobel, 2015; Laursen & Salter, 2014; Zobel et al., 2017) indicates that, in addition to formal appropriation mechanisms (e.g., patents), secrecy, lead time, and process and product complexity are important informal appropriation mechanisms used by individual firms to protect their firm-specific innovative efforts. In a relational contracting context characterized by social norms, both formal and informal appropriation mechanisms can be applied for knowledge sharing and joint ownership and become subject to interorganizational governance and sharing among cooperating participants rather than being retained by individual firms.

The main proposition put forth by this framework is that to understand how firms can create and capture value in an OI setting, future research needs to combine an organizational boundaries perspective with a contracting perspective (see Figure 1). While the former explicates how permeable competence,

FIGURE 1
A Framework and Future Research Agenda for Open Innovation



efficiency, identity, and power boundaries enhance value creation via the exchange of knowledge with a broad set of external parties, the latter specifies how these permeable boundaries can be governed via relational contracts.

This combined perspective raises the question of how firms develop strategies that enable them to combine permeable boundaries with each other as well as with relational contract design to simultaneously create and capture value from their OI approaches (see lower part of Figure 1). The configuration of boundaries and contract design of external partnerships is important for the competitive advantage of firms and, thus, needs to be strategically managed. We argue that one approach particularly useful for developing a better understanding of the strategic management of the permeability and governance of firm boundaries is to adopt a dynamic capabilities perspective (e.g., Teece, 2007; Teece, Pisano, & Shuen, 1997).

A crucial question of OI research refers to how firms can create a competitive advantage in innovation in a world in which sources of innovation are increasingly distributed and can no longer be kept completely secret and protected within the firm's boundaries. A dynamic capabilities perspective can help to shed light on how firms strategically manage the permeability of their interdependent firm boundaries and thereby reconcile value creation and value capture. Adopting Teece's (2007) typology, we suggest that firms need to (1) sense opportunities for configuring permeable boundaries, (2) seize these opportunities by designing relational contracts, and (3) continuously (re-)align permeable boundaries and contract design.

As such, we propose that rather than solely orchestrating their own resource base, firms that are active in OI need to orchestrate their multidimensional boundaries. So far, research on dynamic capabilities has focused on their purpose to modify the firm's internal resource base (e.g., Zahra, Sapienza, & Davidsson, 2006). However, more recently, scholars have emphasized that this purpose needs to be extended to include the modification of external resources and the broader ecosystem surrounding the focal firm (e.g., Schilke, Hu, & Helfat, 2018; Teece, 2007). We argue that OI is an ideal context for studying dynamic capabilities that not only coordinate the resources a focal firm owns but orchestrate a wider set of resources a focal firm accesses or commercializes externally. The capabilities to configure interdependent permeable boundaries, design relational contracts, and continuously (re-)align

permeable boundaries with contract design characterize a specific set of dynamic capabilities in the context of OI that can ultimately lead to competitive advantage. Next, we discuss this set of dynamic capabilities and outline a future research agenda (see Figure 1 for exemplary research questions).

Sensing Opportunities for Open Innovation: Configuring Permeable Boundaries

Sensing capability refers to the mobilization of organizational infrastructure to create, acquire, or shed resources (Katkalo, Pitelis, & Teece, 2010). As outlined in the earlier part of this paper, a multidimensional boundary perspective of OI not only requires the modification of the firm's internal resource base (i.e., via permeable competence boundaries), but involves additional modifications of related firm boundaries. First, the firm's internal resource base extends to a portfolio of external resources that are governed via permeable efficiency boundaries. Second, dynamic capabilities to modify identity boundaries lead to changes in cognitive, emotional, and motivational traits of individuals within and outside the focal firm. This includes shared mental models and cognitive frames as well as organizational and collective identities (see also Schilke et al., 2018). Third, permeable power boundaries affect changes in the external environment and ecosystem (e.g., shaping strategies and behaviors of external actors) that surround the focal firm. This perspective is in line with recent developments in dynamic capabilities research, which call for an extension of dynamic capabilities from a purposeful modification of the firm's internal resource base to include purposeful change of its external environment (e.g., Schilke et al., 2018). Table 1 (above) provides a preliminary list of underlying mechanisms of dynamic sensing capabilities aimed at modifying firm boundaries.

However, sensing capability in an OI context is not just a matter of increasing the permeability of individual boundary types. Clearly, the different types of boundary are interdependent and require interrelated choices regarding their degrees of openness. In other words, it is a matter of configuring different degrees of permeability across multiple and interdependent types of boundaries. As such, an important avenue for future research is to study how the different boundary types relate to each other and interact. These interdependencies among permeable boundaries result in several areas of future research.

First, our multidimensional boundary conception of OI implies a certain order in which firms increase the permeability of their boundaries. As argued above, any OI activity will involve competence and efficiency boundary considerations, while modifications of identity and power boundaries may become relevant only as firms engage more deeply and strategically in OI. Empirical research could test the order in which the permeability of boundary types is enhanced as well as shed more light on the contingencies that require permeability not only on the competence and efficiency dimensions, but also on the identity and power dimensions.

Second, each boundary type is a continuum ranging from closed to semipermeable to completely open. Thus, a focal firm faces choices regarding its positioning on this continuum with respect to each boundary type. Choosing a certain degree of openness on one dimension is likely to influence the effective openness on other dimensions. Future research needs to evaluate the appropriateness of different combinations of boundary types that vary with regard to their levels of openness. Which combination of openness on the different boundary dimensions is optimal? This configurational perspective allows the study of OI as a complex phenomenon that is described in terms of multiple theoretical dimensions, wherein specific configurations of these interdependent dimensions will result in optimal outcomes (Fiss, 2011).

Third, and relatedly, this includes studying the extent to which boundary types and their permeability are complementary (openness on one dimension *increases* the marginal benefits derived from openness on another dimension) or substitutive (openness on one dimension *decreases* the marginal benefits derived from openness on another dimension). In this context, it is also relevant to understand to what extent closed boundaries and open boundaries can coexist. For example, future studies could examine to what extent and how firms can reconcile closed identity boundaries (i.e., firms with a strong single organizational identity) with open competence boundaries (i.e., firms that absorb and desorb resources as well as access resource portfolios at the network level).

A dynamic capabilities perspective can inform such questions, as it highlights the importance of co-specialization in strategic decision making (Teece, 1986, 2007). While the traditional framework focuses on the complementarity of assets, we propose that the context of OI extends this perspective to a focus on complementarity of firm boundaries.

Future research should explicate a set of dynamic capabilities that enable firms, active in OI, to sense new combinations of boundaries and configure their permeability accordingly.

Finally, any particular instance of a dynamic capability is context dependent with respect to the setting (e.g., firm, industry, and geography) in which it develops and is employed (Schilke et al., 2018). For instance, prior research has established that the effect of dynamic capabilities on competitive advantage is contingent on the level of dynamism of a firm's external environment (Schilke, 2014). Beyond general dynamism, it is important to relate future research to a systematic analysis of possible industry-specific circumstances that affect the effectiveness of permeable boundaries and their combinations.

An interesting analytical framework can be found in Pavitt's taxonomy of sectoral patterns of innovation (Pavitt, 1984; Tidd, Bessant, & Pavitt, 1997), widely used in innovation studies (see Bogliacino & Pianta, 2016, for a taxonomy update and an overview of studies based on Pavitt's work). This taxonomy indicates that innovation in science-based industries, such as electronics, chemicals, and pharmaceuticals, relies on internal R&D input but also on substantial external input from the public science infrastructure as well as from specialized suppliers. Innovation in scale-intensive industries, such as steel, glass, and assembly-based industries, depends on both internal R&D and external innovation input from a variety of suppliers. Innovation in information-intensive service industries, such as finance, retailing, publishing, and travel, is largely dependent on internal information technology-based innovation efforts and input from specialized suppliers.

In supplier-dominated industries, such as agriculture and traditional manufacturing, innovation is characterized by little or no internal firm resources; the main source of innovation is dependent on suppliers. Specialized supplier industries, such as machinery and instruments, are design and development oriented, and their innovation efforts are based on both in-house capabilities and substantial inputs from their customers. These variations in the relative importance of internal resources and external innovation resources add an important, encompassing component to the research agenda that can further our understanding of OI and the configurations of firm boundaries. As such, which type of boundary conception dominates a firm's logic may not be determined only by the degree and types of OI activities but also by the industrial environment in which the firm operates.

Seizing Opportunities From Open Innovation: Designing Relational Contracts

Seizing capability refers to how firms capture value from their sensed opportunities (Teece, 2007). Once different boundary types become more permeable, they must be addressed, or seized, via appropriate governance structures. We argue that this requires the design of relational contracts (see Figure 1, above). Relational contracts are hard to build and refine (Gibbons & Henderson, 2012) and as such constitute a crucial dynamic capability in the context of OI. However, so far, the understanding of contract design of interorganizational relationships in an OI context is rather limited. Most insights come from the related literature on alliances, licensing, and interorganizational governance in general, but even within that body of literature, the specific implications for contract design appear to be of a rather ad hoc nature. Going beyond this ad hoc nature requires both a better understanding of the general nature of contract design and a deeper understanding of contractual governance through each of the organizational boundary types. Such research should shed light on the underlying routines and processes of seizing OI opportunities via relational contracts.

Addressing or seizing opportunities from permeable boundaries requires the effective development of relational contracts between OI partners. Trust and social norms need to be established to allow multiple partners to capture value from their joint innovative effort. However, in terms of the general nature of contract design, it appears that research so far has generated only limited understanding of the actual relational aspects in interorganizational contracting. Many studies refer to relational contract design, whereas the empirical findings of these studies suggest that the interorganizational relationships studied are in effect still more of a neoclassical contract design (see, e.g., Lumineau & Oxley, 2012; Luo, 2002; Parkhe, 1993). Obviously, contract design elements such as bilateral governance, maintaining long-term relationships, and conflict resolution through arbitration, as key elements of neoclassical contract design, go beyond a classical contract design perspective. However, they also fall short of relational contracting where contracts are incomplete by design, the written contract is supportive of developing the relationship between parties, and social norms based on trust guide the relationship (Hagedoorn & Heslen, 2007).

Rather than referring to formal neoclassical contract design as relational contracting because some

clauses hint at “open” contracts, it might be more relevant for future research to develop a deeper understanding of the exact nature of OI contractual governance. Further understanding the actual role and importance of trust, transparency, flexibility, reciprocity, options for internal arbitration and renegotiations, and the status of the actual written contract is crucial for achieving a better perspective on how firms seize opportunities across permeable boundaries in an OI context. This general understanding of contract design in OI goes beyond dyadic interfirm alliances and includes a broad range of interorganizational relationships with customers, suppliers, competitors, research institutes, universities, intermediaries, communities of innovation, and individual inventors. Given the multiplicity of partners, future research should investigate how OI partners develop a shared understanding of their relational contracts, given their open-ended and tacit nature (see also Gibbons & Henderson, 2012).

In addition to a better general understanding of the relational design of contracts, seizing opportunities in an OI context will require matching this contract design with the different types of permeable firm boundaries. Our analysis of the existing literature revealed that the more specific understanding of contract design in light of permeable boundaries is inspired by a relatively small body of research on interorganizational collaboration rather than by a specific body of OI literature. For instance, in reference to permeable efficiency boundaries and contractual dimensions of OI, there is a small body of relevant OI-related literature on IP management (e.g., Alexy et al., 2009; Hagedoorn & Zobel, 2015). However, the other relevant aspects of contractual dimensions of OI affected by the permeability of organizational boundaries have so far received little or no attention in the OI literature, and certainly not in the context of the diverse set of OI partners. As such, future research should focus on the implications of the permeability of each of the organizational boundaries for specific contract designs of relationships with different OI partners.

The contractual dimensions of OI, as listed in Table 1 (above), as well as the exemplary research questions in Figure 1 (above), indicate a pervasive research agenda as to the further study of the role and relative importance of these contractual dimensions in the contract design of a broad range of OI relationships. Future research could focus on the specific role and the relevance of these contractual dimensions as firms are confronted with the impact of increasing permeability of their organizational

boundaries on the governance of their relationships. In addition, as indicated above, interesting topics for future research on OI-related contract design could refer to the impact of interdependencies of different boundary types on the relative importance of particular contract design elements. More specifically, does the relative importance of the permeability of organizational boundaries through competence, efficiency, identity, and power (or lack thereof) affect the content, nature, and wording of specific contract clauses in OI-related contracts?

Reconfiguring Opportunities of Open Innovation: Continuous (Re-)Alignment of Permeable Boundaries and Contract Design

Reconfiguring capabilities concern how boundaries and contracts are continuously recombined as focal firms' OI activities change over time. As firms engage in new OI activities (e.g., by changing their partner portfolio or the depth with which they collaborate with different partner types), they will need to reassess how these activities align with their firm boundaries. For instance, engaging with a broader portfolio of partner types might require modifications in a focal firm's competence boundaries, such as enhanced absorptive capacity for integrating external knowledge from these diverse sources. Increases in depth of collaboration create opportunities for enhancing the permeability of identity and power boundaries, as the deep nature of the collaboration enables the formation of a collective identity and allows the focal firm to strategically influence its partner. As such, reconfiguration is needed to maintain the evolutionary fitness (Helfat et al., 2007) of boundary configurations and, if necessary, to escape from unfavorable path dependencies (Teece, 2007). Such reconfigurations will need to take into account the interdependencies among boundaries, as choice for one boundary type (e.g., power boundaries) will have implications for other boundary types (e.g., identity boundaries).

At the same time, as firms change their approach to OI and adjust the permeability of firm boundaries, they face implications in terms of governance and value capture. In particular, with changing OI activities and shifting firm boundaries, there is a risk of unintended knowledge spillovers and adverse IP allocation to and by partners. As the permeability of boundaries changes, it is necessary to assess the relative efficacy of specific contractual dimensions (see Table 1, above) vis-à-vis the other dimensions. Different combinations of boundaries and their

permeability may require different combinations of contractual design elements. To what extent and under which conditions can informal contractual dimensions (e.g., trust, solidarity, transparency, communication, and sharing of resources) play a role in OI value capture compared to other relational, yet more clause-based, written and formal contractual dimensions, such as contractual flexibility, renegotiation options, IP allocation, amicable terms of termination, and terms of decision making? In other words, formal and informal dimensions might play different roles, depending not only on the specifics of the permeability of boundaries but also on the nature of partners, as OI firms face a wide variety of partners, ranging from public institutions to competitors, that create different conditions for value capture.

As firms that engage in OI are known to apply a broad set of forms of governance that regulate knowledge sharing and development, we are also in need of a deeper understanding of the actual relational nature of these different forms of governance and the implications for value capture. For instance, licensing contracts are traditionally seen from the perspective of somewhat classical or at best neoclassical contract design, whereas partnerships and joint ventures tend to be seen more from a relational contract design perspective (Hagedoorn & Hesen, 2007). For the broad set of forms of governance and relationships in which firms can engage through OI and that are instrumental in the actual permeability of organizational boundaries, there is a clear need for a better understanding of the expediency (or lack thereof) for particular dimensions of relational contract design. For instance, we need a better understanding of the actual value capture implications for informal and formal dimensions of the relational contract design for different OI relationships with different partners. Given the range of alternative options, it might even be interesting, under certain conditions (e.g., with straightforward outward OI through licensing contracts or with more standard cooperation with suppliers), to opt for a contract design to capture value that is more classical or neoclassical than relational in nature. As such, future research should shed light on the microfoundations of reconfiguration capabilities, which aim at continuously (re-)aligning OI activities with the permeability of boundaries and contract design.

CONCLUSION

In this paper, we take an established problem in the OI domain—the paradox of openness (e.g.,

Laursen & Salter, 2014; Wadhwa et al., 2017; Wang et al., 2017)—and deliver a new perspective for researching this problem. First, beyond external search openness (Laursen & Salter, 2006), we suggest that the permeability of boundaries constitutes a more encompassing organizational perspective of OI that sheds light on value creation. This organizational boundary perspective suggests that OI is a complex phenomenon that should be studied along four dimensions: competence, efficiency, identity, and power boundaries. This comprehensive perspective facilitates a more profound theoretical foundation of future OI research, as it encourages connections to other established theories and constructs associated with the different boundary types. Second, an organizational boundary perspective of OI has important implications for our understanding of the governance of interorganizational relationships and subsequent value capture. We argue that governance across boundaries calls for a more flexible relational perspective on contract design that goes beyond the consideration of classical value capture mechanisms, such as written contracts and IP.

Taking stock of existing literature, we identified mechanisms of permeable boundaries and contract design that illustrate the usefulness of this dual perspective. Beyond this analysis, we developed a set of research questions that can shed further light on how permeable boundaries and relational contract design enable value creation and capture in an OI context. Finally, we proposed a novel conceptual framework that investigates OI from a dynamic capability perspective. This framework informs future research on how firms can strategically manage configurations of interdependent firm boundaries and contract design to create and capture value from OI.

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