

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

International Journal of Project Management

journal homepage: www.elsevier.com/locate/ijproman

Trajectories towards balancing value creation and capture: Resolution paths and tension loops in open innovation projects

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ARTICLE INFO

Keywords:

Value creation
Value capture
Tension loops
Resolution paths
Open innovation projects
Persisting tensions

ABSTRACT

This study aims to elevate the current understanding of value creation and value capture tensions that emerge in open innovation projects and of their potential solutions. In contrast with prior studies that often suggest specific solutions to individual tensions, our study takes an integrative approach by considering complex (bundles of) tensions and potential solutions to these. The study employs qualitative methods and builds on interview data from six case companies and a group of expert informants. We investigate unfolding events from the point when value creation – value capture tensions are identified in open innovation projects, to the search for their solutions. We label such sequences of unfolding events as *trajectories*. Our findings reveal two types of trajectories: *resolution paths*, which are trajectories from initial tensions to solutions, and *tension loops*, where initial tensions persist and/or new tensions emerge after solutions are enforced. We analyze a total of 17 trajectories, of which seven are marked as resolution paths, and ten represent tension loops. For the majority of the tension loops in our data (eight out of ten) the tensions remain unresolved. We further categorize the types of tensions and discuss the implications of our results for researchers and practitioners.

1. Introduction

During recent years, interest in the intersection of innovation management and project management has grown (Midler, Killen, & Kock, 2016). This is partly in response to the increasingly connected and networked forms of generating value, where opening up innovation projects brings benefits such as sharing risks and costs (Ahn, Kim, & Moon, 2017; Chesbrough, 2003; Huff, 2016; Lakemond, Bengtsson, Laursen, & Tell, 2016). Open innovation (OI), which entails distributed innovation processes based on purposively managed knowledge exchange (Chesbrough, Lettl, & Ritter, 2019), calls for balancing value creation and value capture (Appleyard & Chesbrough, 2017; Laursen & Salter, 2014). More collaborative and open forms of innovation require careful approaches with regard to organizing innovation projects (Srivannaboon & Munkongsujarit, 2016). Therefore, integrative practices that direct and control innovation activities (Brunswick & Vanhaverbeke, 2015) and respond to emerging opportunities and threats are needed.

Involving external partners in innovation projects enables, on one hand, generating new combinations of knowledge, yet, on the other hand, it inherently generates tensions (Chesbrough et al., 2019; Laursen & Salter, 2014; Lorenz & Veer, 2019). This relates to the paradox of

openness, which underlines tensions between creating and capturing value in OI (Bogers, 2011; Laursen & Salter, 2014). For example, OI projects may have wide geographical reach, which may not match well with territorial protection systems for intellectual property (Trimble, 2014). Such mismatches enable opportunistic behavior from other actors - even by the participants in the OI projects - and may lead to unwanted collaboration outcomes such as misappropriation of intellectual property (IP). The mere fear or misappropriation could have negative consequences such as reduced openness (Lorenz & Veer, 2019), and raise questions of ethics and fairness (see Faullant, Fuller, & Hutter, 2017; Franke, Keinz, & Klausberger, 2013, for studies in crowdsourcing contexts). Issues such as misappropriation, knowledge leakage or unintended holding back of relevant information endanger both competitiveness of individual organizations, as well as project success (Buss & Peukert, 2015; EC, 2012; Hurmelinna, Kyläheiko, & Jauhiainen, 2007; Lorenz & Veer, 2019; Wadhwa, Freitas, & Sarkar, 2017). Cases of misappropriation in the media, e.g. the Infloows-Corbis case described by the New York Times (Lohr, 2010), clearly illustrate such severe outcomes and related consequences. In the mentioned case, the two companies, Infloows and Corbis, had signed a contractual agreement to jointly develop a new product; however, after several months Corbis cancelled the agreement and went on to independently patent the technology

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developed together with Inflows, while at the same time suing Inflows for infringement. After a lawsuit that lasted several years, the U.S. court found Corbis guilty of trade secret misappropriation (Lohr, 2010). This example serves to illustrate some negative repercussions of the imbalance between creating and capturing value in OI settings.

In the past few years, tensions between creating and capturing value in OI related to the paradox of openness have received increasing attention (Arora, Athreye, & Huang, 2016; Foege, Lauritzen, Tietze, & Salge, 2019; Lauritzen & Karafyllia, 2019; Laursen & Salter, 2014; Niesten & Stefan, 2019; Wadhwa et al., 2017), yet, several unanswered issues remain. For instance, Lorenz and Veer (2019) suggest future investigation into misappropriation, while Wadhwa et al. (2017) propose further inquiry into the matter of resolving value creation-capture tensions. One particular challenge here is that extant research has ‘sliced’ the puzzle of value creation and appropriation in OI into singular problems, which, in turn, have tailored yet confined solutions. We argue that such solutions only partially solve tensions, or only do so in specific contexts. It is therefore still unclear how more complex tensions can be tackled so that viable balance between value creation and value capture can be reached. Recent studies formulate this as an issue of combining differentiation and integration (Foege et al., 2019; Lauritzen & Karafyllia, 2019). Additional challenges entail, for instance, that value creation and capture tensions are typically addressed at firm- or relationship level (e.g. Appleyard & Chesbrough, 2017), rather than from the point of view of project management. Moreover, one common denominator in studies investigating value creation-capture tensions is the use of quantitative methods. One drawback in investigating a complex phenomenon by employing quantitative methods is that the number of variables that may be investigated simultaneously is limited. Therefore, we argue that the complexity of tensions between creating and capturing value – let alone how these are solved – in OI is not yet fully understood.

Given the above pinpointed challenges related to the understanding and investigation of value creation and capture in OI, we assert that project management is increasingly relevant in networked settings, as value generation and firm-specific benefits do not accrue automatically to the involved parties. The actions taken to reach balance between value creation and capture are of utmost importance, but the complexity of the setting challenges the managerial activity in many ways.

In line with the above considerations, our study aims to provide a better understanding of *the trajectories from value creation and value capture tensions to their solutions in OI projects*: we will explore theoretical and empirical materials to find out *what kind of challenges are characteristic to such projects, and what kind of solutions can be suggested to manage tensions* in such way that all partners in a given open innovation project capture proportional value from their joint creative endeavors. We pursue this goal, first, by examining existing literature on OI projects and the related elements of value creation and capture. We then turn to qualitative empirical evidence in order to explore the tensions in such projects and examine how they can be managed successfully. We close the discussion by deriving the theoretical contributions from the preceding discussion, by introducing managerial implications, and by evaluating the limitations and suggesting future research areas.

2. Theoretical background

In this study, we follow the example of Lakemond et al. (2016), 334) in defining project management as “the firm’s overall use of project management techniques, such as formal plans and milestones, formal evaluations of collaborative projects, and provision of incentives to increase collaborative partners’ efforts, aimed at controlling and managing collaborative projects.” We focus especially on the latter mentioned features, as those connect most closely to the OI context. Along these lines of thinking, project management comprises managerial efforts to mitigate agency and cooperation problems in OI (Lakemond et al., 2016).

As Midler et al. (2016), 3) conclude from existing literature, “the importance of tailoring management approaches to the context is a recurrent theme in both fields”: project and innovation management. Therefore, the central features of OI environments need to be acknowledged.

2.1. Project management and value creation – capture tensions in open innovation projects

The growing tendency to open up innovation processes in order to maintain competitive advantage has been widely acknowledged and investigated by scholars (Bogers et al., 2017; Chesbrough, 2003; Dahlander & Gann, 2010; Huizingh, 2011). In many organizations, innovation strategies are realized through product development projects, and OI also has this feature (Bonesso, Comacchio, & Pizzi, 2014; DeFillippi & Sydow, 2016; Gemünden, Killen, & Kock, 2013; Srivannaboon & Munkongsujarit, 2016). Like in-house innovation projects, OI projects also have frames set by scheduling, budgeting, and goals. Planning and execution, as well as suitable structures, are needed to handle various risks in such projects. Additionally, knowledge exploration and flexibility requirements in OI undoubtedly invite uncertainty and vagueness. Hence, viewing OI as a series of projects is not uncustomary (Bonesso et al., 2014; Salge, Farchi, Barrett, & Dopson, 2013).

Specific challenges in OI projects spur, from tensions between generating and capturing value. Paraphrasing Arrow (1962); Laursen and Salter (2014) highlight increasingly complex interactions that follow from partners’ needs to jointly create value in OI, while each of them aims to capture part of that value for their own organization. While loosening control may be a strategy (see, e.g., Alexy, West, Klapper, & Reitzig, 2018), in the background, each partner is motivated to gain some share of the joint benefits (Chesbrough et al., 2019). We refer to the latter alternatively as value capture or appropriation. The two terms are meant to reflect the successful allotment of financial as well as social or other types of benefits from joint value creation in OI. The tensions between value generation and appropriation stem, for instance, from value creation occurring at the interorganizational level, and the organization-specific nature of value capture: the two require somewhat contrasting strategies, yet both are inherently present. According to Bledow, Frese, Anderson, Erez, & Farr (2009) conflicting demands lay at the heart of tensions in innovation management, hence contrasting strategies or approaches between value creation and capture are highly likely to spur tensions in OI projects. Additionally, tensions may persist over time, thus shaping cycles of tensions, which may have positive or negative outcomes, contingent upon the way the tensions are tackled (Schad, Lewis, Raisch, & Smith, 2016; Smith & Lewis, 2011). However, the potential persistence of value creation-capture tensions in OI has been scarcely investigated.

Various streams of literature have pinpointed different types of tensions between value creation and value capture. These have their distinctive points of view that, combined can provide direction for investigating complex entities. For instance, research streams focusing on idea incubation, small and medium enterprises, start-ups, etc. often emphasize tensions related to asymmetry (De Groote & Backmann, 2020; Diestre & Rajagopalan, 2012; Hallen, Katila, & Rosenberger, 2014; Kalaignanam, Shankar, & Varadarajan, 2007; Oughton, Mortara, & Minshall, 2013; Rayna & Striukova, 2010). High asymmetry between partners typically concerns firm size, but there may be a multitude of underlying issues, such as asymmetry in terms of resources or bargaining power, that are to be acknowledged. Asymmetry tensions may also pertain to specific resources, such as knowledge about IP protection, in smaller firms (Rayna & Striukova, 2010). Tensions stemming from asymmetry can further relate to position. For example, Arora et al. (2016) suggest that technology leaders are more prone to unintended knowledge spillovers in innovation collaboration compared to firms that are so-called followers. Organizational goals and culture might also spur asymmetry-related tensions. Perkmann & Schildt (2015),

for instance, highlight the differences between academic institutions and firms in terms of incentives to publish versus commercialize new knowledge.

As another example, research streams on alliances and networks, venture capital, and licensing bring up tensions related to connectedness or interdependency among actors (e.g. Hernandez, Sanders, & Tuschke, 2015) and goals and interests (mis)alignment (e.g. Jordan, 2004). In fact, network literature well acknowledges paradoxical nature of being (dis)connected (see, e.g., Håkansson & Ford, 2002). While networking enables access to new knowledge, it also creates problems related to trust and communication between partners. On the positive side, collaborating with different partners (differentiated knowledge bases) may be beneficial for innovation (see e.g. Asheim, Boschma, & Cooke, 2011; Contractor & Ra, 2002) and, furthermore, working with different types of partners might have distinct effects on project performance (Du, Leten, & Vanhaverbeke, 2014a; 2014b). Co-opetition, i.e. collaborating with competing partners (see e.g. Bengtsson & Kock, 2000; 2014; Dagnino, 2009; Ritala & Hurmelinna-Laukkanen, 2013), might also boost performance, yet, at the same time could intensify tensions and change their nature. Tensions that relate to interconnectedness are further signaled by Chesbrough & Schwartz (2007), who turn attention to business objectives. Previous research shows that lack of alignment and lack of clarity regarding partnership objectives may have negative effects on value appropriation (see e.g. Jordan, 2004; Li, Eden, Hitt, & Ireland, 2008). Likewise, activities and structures for organizing the partnerships and joint work may generate more and less unpredicted changes and related tensions. For example, OI partners might each take the role of idea originators sequentially or simultaneously, which may change the network balance (Enkel, Gassmann, & Chesbrough, 2009; Piller & West, 2014).

Tensions related to contractual limitations (Hagedoorn & Heslen, 2007; Kloyer & Scholderer, 2012) and weak points of IP protection (Erstling & Boutillon, 2005; Trimble, 2014) could be included under the broader umbrella of appropriability (see Teece., 1986). Literature on appropriability and intellectual property (IP) rights points toward other types of tensions by addressing the challenges of appropriability and IP protection in the context of collaborative activities (e.g. Hall, 2005; Hurmelinna-Laukkanen, Sainio, & Jauhiainen, 2008; 2012; Neuhäusler, 2012). For example, Buss & Peukert (2015) highlight linkages between R&D outsourcing and IP infringement. Lorenz & Veer (2019), in turn, pinpoint that firms whose IP has been misappropriated while not protected by formal IP protection mechanisms are less likely to have subsequent R&D collaboration than companies whose infringed IP was formally protected. Inadequate IP protection could make revealing knowledge risky (Giannopoulou, Yström, & Ollila, 2011) and may keep firms from entering into collaboration (Heiman & Nickerson, 2004), but overly strong protection may also limit efficient knowledge sharing (e.g. Frishammar, Ericsson, & Patel, 2015). The issue of IP ownership in joint projects is often difficult to manage, as co-owning IP may have downsides, particularly in collaborations with partners from the same industry (see e.g. Belderbos, Cassiman, Faems, Leten, & Van Looy, 2014). Early phases of the innovation process may strengthen appropriability-related tensions as uncertainty is high (see e.g. Vanhaverbeke, Van de Vrande, & Chesbrough, 2008). Moreover, IP boundaries may be difficult to delineate ex ante, which may become a challenge ex post due to the lack of clarity as to where the boundaries should be drawn (Fjeldstad, Snow, Miles, & Lettl, 2012). IP-related issues also emphasize possibly different levels at which value creation and capture occur: for example, even if there is an agreement at inter-organizational level on how IP issues are managed, individual employees may act in a way that undermines the ideas of project managers (see, e.g. Olander, Hurmelinna-Laukkanen, & Heilmann, 2015). Appropriability-related tensions might further stem from open-closed dynamics (see Granstrand & Holgersson,

2014). Here, timing may be crucial (Bahemia, Sillince, & Vanhaverbeke, 2018) and time has similarly proven to have important effects in projects (Söderlund, 2002; 2012). Therefore, timing issues might also be linked to value creation and capture tensions in OI projects. Finally, the complexity of projects (Brady & Davies, 2014; Martinsuo & Ahola, 2010; Wang, Lin, & Huang, 2010; Winkelbach & Walter, 2015) could increase uncertainty and risks and may add to appropriability-, asymmetry- or network-related tensions in OI projects.

2.2. Resolving tensions – project management approaches

Prior research proposes several mechanisms as possible project management solutions to value creation and capture challenges in OI projects. For instance, to reduce uncertainties and to limit challenges related to issues such as information asymmetry, collaborating with ‘known’ partners, or with partners that have similar knowledge bases would be a potential solution (Katila & Mang, 2003). While working with known OI partners may have advantages, searching for new OI partners may also be required in OI projects. This could be linked to the sensing function of dynamic capabilities (Teece, 2007). Additionally, formalizing the collaboration and agreeing upon value capture aspects with new or familiar partners translates into a seizing function (Teece, 2007; 2018). Subsequently, reconfiguration would be needed to accommodate new variables and adjust the business model for the organizations participating in OI projects. However, these issues could also generate further conflicts with OI project partners, therefore partner selection, visioning and coordination are needed (Hurmelinna-Laukkanen & Natti, 2018). Previous collaboration experience is also regarded beneficial in OI projects, as it indicates lower risks of losing proprietary knowledge (Dekker, 2008; Katila & Mang, 2003), while mutual trust generally decreases (perceived) risks of misappropriation (Dekker, 2008; Jordan, 2004) and it is therefore crucial to structure project teams and introduce management practices that enhance trust (see Dhanaraj & Parkhe, 2006). However, caution is warranted, as excessive trust is found to lead to unwanted knowledge leakage, increasing risks of misappropriation (Jiang, Bao, Xie, & Gao, 2016). Solutions to IP and appropriation challenges have also been considered in prior studies. For instance, in order to avoid challenges related to disclosure and the ‘public good’ nature of knowledge, interactive revealing (e.g. Jarvenpaa & Valikangas, 2014) or gradual or selective revealing could be enforced (Alexy & Reitzig, 2013; Alexy et al., 2018). In addition, relying on strong appropriability regimes is endorsed in previous studies as a solution for securing value capture, especially when competitors are involved (Henttonen, Hurmelinna-Laukkanen, & Ritala, 2016; Kasch & Dowling, 2008; Ritala & Hurmelinna-Laukkanen, 2013), e.g. using mechanisms such as patents for safe knowledge sharing (Hurmelinna-Laukkanen, 2009). Likewise, formal mechanisms like milestone options in contracts, have been suggested as solutions to IP-related issues (see e.g. Bhattacharya, Gaba, & Hasija, 2015). While it is possible that some elements in a given OI project are kept closed when others are opened (Alexy et al., 2018), withholding knowledge may lead to suboptimal results, or to obstacles to development of trust.

Thus, it could be argued that though there are solutions available that potentially balance value creation and capture (see, e.g., DeFillippi & Sydow, 2016; Lakemond et al., 2016), such solutions may backfire and their suitability for OI projects calls for further investigation. This indicates that some solutions could potentially generate new challenges, which would need to be addressed by yet another set of solutions. In addition to the issue of potential subsequent tensions following the introduction of solutions, we note that while scholars have proposed solutions for dealing with different types of issues separately – e.g., selective revealing as a means to mitigate excessive protection (e.g. Henkel, 2006) – extant research is lacking an integrative approach.

The one-on-one logic might help solve individual types of tensions, but it does not fully resolve complex tensions. Managing tensions needs to be considered from different angles simultaneously (Lauritzen & Karafyllia, 2019), especially as the increased complexity is likely to unfold in varying forms and originate from varying sources (Niesten & Stefan, 2019). As current research is lacking comprehensive, in-depth insights into solutions for complex and/or recurring tensions between value creation and capture, we turn to empirical evidence.

3. Methods

3.1. Research context and data collection

This study employs exploratory, qualitative research methods (Eisenhardt & Graebner, 2007; Gioia, Corley, & Hamilton, 2013; Yin, 2013). We selected six case companies that would provide insights about the types of tensions, as well as solutions enforced, and a group of experts that would contribute with a wider overview on the possible solutions for the value creation – value capture tensions. We selected the case companies based on richness of information (Coyné, 1997) and on variety in terms of contexts, representing various industries, maturity-levels, and sizes. Prior studies on OI have recommended closer exploration of value creation – value capture tensions, particularly outside the ICT sector (Appleyard & Chesbrough, 2017). For instance, tensions have been noted to exist in projects from sectors such as oil and gas (Olsen, Haugland, Karlsen, & Husøy, 2005), mining (Frishammar et al., 2015), the energy sector (Niesten & Jolink, 2012), or logistics industry (Klein & Rai, 2009). In our study, Case firms A and D are large companies in oil and gas industry. Company D is also active in other sectors, e.g., paper and pulp. Companies B and C operate in the logistics and transport sector; the former is a start-up, while the latter is an established large company active in many countries across the globe. Case company E is an SME in the energy sector, and Company F is an established large firm in mining and construction and engineering sectors, among others. Such variety in the cases is helpful in allowing researchers to recognize relevant patterns (Palinkas et al., 2015).

The experts, for their part, each have several decades of experience in different key roles in respect to OI projects, which helps us to push the study of the patterns beyond the case firms. Experts 1 and 2 have leading roles in organizations that act as OI intermediaries. Expert 3 has decades of experience in being R&D and OI VP in a large firm recognized for its success in OI. Expert 4 is active in a venture capital unit of a large company and has extensive experience in asymmetric collaborations between small and large firms. Experts 5 and 6 are specialized in the legal side of IP protection. The original dataset included a seventh expert, but for the purposes of this study we chose not to use data from that particular interview because the main topics discussed in the interview are not in the focus of this paper.

Central to the interviews were the informants' perceptions (Glaser & Strauss, 1967) of the tensions between creating and appropriating value in OI projects, and how such tensions might be resolved, i.e. managed successfully. The company representatives were asked to consider specific projects, while the expert informants were requested to provide more general overviews based on their long-term experiences. The experts could provide insight on the types of tensions, but they did not necessarily connect those to specific situations to the same extent as company representatives. Therefore, we used the information from the companies to identify OI project -specific tensions and their solutions, and then extended the knowledge of the observed patterns by adding to this the more general insights received from the experts. For the purpose of this manuscript, data from 15 recorded interviews is analyzed, nine of which are interviews with managers from the case companies' representatives and six interviews with expert informants. The interviews were conducted during 2017 using a semi-structured approach. The duration of the recorded and transcribed interviews ranged between 30 and 90 min, with most interviews lasting approximately 60 min. Prior to

the recorded and transcribed interviews, there were also five unrecorded discussions with some of the informants. These discussions were part of the "snowball sampling" approach. During these unrecorded discussions we were able to establish if the case companies fit the selection criteria and ask for contact information of additional key contacts within the case companies. We append key interview questions in Appendix 1. Additional materials such as notes and email correspondence with the informants pertaining to the investigated topic were also included in the data analysis. The empirical materials amount to approximately 200 pages. Table 1 shows details about the interviewed informants - both managers from the case companies, and expert informants.

3.2. Data analysis

Since the aim of this study is to pinpoint trajectories from tensions to solutions in OI projects, we analyzed the collected data by first investigating the value creation–value appropriation tensions that informants perceived and, second, by analyzing suggested solutions for managing said tensions. We conducted the analysis using the NVivo software tool.

Following a grounded theory approach (Strauss & Corbin, 1998) we first formulated categories by distributing data into groups, and thereafter advanced our analysis by identifying connections between the categories. We examined the events originating from tensions between creating and capturing value, subsequently leading to potential solutions in OI projects. We dub such streams of events as *trajectories* from tensions to solutions. The first author conducted preliminary analyses in NVivo and subsequently all three authors further discussed and agreed upon categories and adjacent linkages. Specifically, we found that the tensions and solutions could be considered to have a temporal dimension and advance in specific phases. Hence, the trajectories from tensions to solutions would encapsulate several phases. In the phases, we could further pinpoint different themes for tensions and solutions. These are discussed in more detail and reflected to extant research in the discussion section.

After having pinpointed the trajectories in our data, as well as the types of tensions and solutions, we proceeded to determine linkages between these, and built a storyline. We uncovered that in some cases, the phases characterized by tension recurred even after initial solutions were employed. This triggered a dichotomy into two types of trajectories: *resolution paths*, i.e. the trajectories from tension to solution (that we expected to find in our data), and *tension loops*, i.e. instances where a given path comes back to the same tensions although plausible solutions have been enforced or, alternatively, where new tensions might emerge despite solutions being applied. This leads to the persistence of value creation–capture tensions beyond their initial state. The two types of trajectories, i.e. resolution paths and tension loops, suggest different ways of linking the previously identified phases, and also the underlying tensions and solutions. We further delineate broader and narrower categories of tensions and solutions. The broader categories of tensions - and partly corresponding solutions - can be linked to the literature streams reviewed in the theory section, i.e. asymmetries in OI collaboration between partners (e.g. between smaller and larger firms - De Groote & Backmann, 2020; Diestre & Rajagopalan, 2012; Hallen et al., 2014; Oughton et al., 2013); partner-specific issues investigated in alliances and networks: e.g. interdependency among actors (Hernandez et al., 2015), opportunism (Bhattacharya et al., 2015) and partner goals and interests (mis)alignment (e.g. Jordan, 2004); as well as contractual and IP protection limitations (Erstling & Boutillon, 2005; Hagedoorn & Hesén, 2007; Kloyer & Scholderer, 2012; Trimble, 2014). Additionally, we identify two narrower categories of tensions and one of solutions. Finally, we map these categories (and their subcategories, in the case of broader categories) to determine which configurations of specific types of tensions and solutions are successful (resolution paths) and which are less successful, causing tensions to persist (tension loops). The linkages between them are weaved into a story in the Findings section.

Table 1
Details about interviewed informants.

Company (size; industry) / Expert (industry)	Company headquarters (country)	Informants interviewed in recorded interviews (country)	Informants interviewed in unrecorded discussion (location)	Total number of informants interviewed (recorded + unrecorded interviews)	Recorded interviews*
Company A (Large; Oil and Gas)	U.K.	Project Engineering Manager (Norway) Engineering Manager Global (U.K.) Engineering Manager (Norway) Head of IP Department (France)	Project Engineering Manager (Norway) Technology Manager (U.K.)	5	3
Company B (Small; Transport and Logistics)	Sweden	Co-founder (Sweden) External Advisor (Sweden)	External Advisor (Sweden)	2	2
Company C (Large; Transport and Logistics)	Germany	Head of IP Department (Germany)	Head of IP Department (Germany) Patent Consultant (Germany)	2	1
Company D (Large; Pulp and Paper, Oil and Gas, etc.)	Finland	Industrial Engineering Manager (Sweden)	-	1	1
Company E (Medium; Energy Sector)	Sweden	Head of Business Unit (Sweden)	-	1	1
Company F (Large; Mining and Construction Equipment)	Sweden	Head of Strategic Research (Sweden) Head of Business Innovation (Sweden)	VP Technology (Sweden)	3	1
Expert 1 (Innovation Management Services)	Netherlands	Strategic Alliance Director		1	1
Expert 2 (Innovation Management Services)	U.S.A.	CEO at Open Innovation Service Provider		1	1
Expert 3 (Consumer Goods)	U.K.	VP Operations and Open Innovation		1	1
Expert 4 (Chemicals)	U.S.A.	Venture Capital and Innovation		1	1
Expert 5 (Legal Sector)	Netherlands	IP Attorney		1	1
Expert 6 (Legal Sector)	Belgium	IP Attorney		1	1

* In some interviews of the case companies' representatives, two or several managers were interviewed during the same meeting.

4. Findings

4.1. Trajectories from identifying tensions to searching for solutions - Overview

Our findings identify trajectories from value creation – capture tensions to solutions in OI projects. In the following we describe and analyze a total of 17 such trajectories. Our analysis reveals that the trajectories have a temporal dimension and hence encompass several phases. Specifically, the trajectories pinpointed in our findings range between two and four phases – we number these phases using roman numerals from I to IV. Phase I, marking *initial tensions*, distinguishes the moment when actors begin to perceive tensions (t_1). At a later point (t_2) *solutions* (II) are suggested, which represents the second phase in the trajectories. While all 17 trajectories contain the first two phases, some trajectories continue beyond phase II. Particularly, in some cases tensions recur or new tensions surface after solutions are introduced. We label this third phase as *persisting or new tensions* (III). Although tensions in phases I and III may overlap, they occur at different points in time, t_1 and t_3 respectively, and have at least some alteration in terms of their contents when the two points in time are compared. Finally, in a couple of trajectories there is a fourth phase, where *further solutions* (IV) are introduced at t_4 and tensions appear to be successfully mitigated.

The four phases comprise two main types of trajectories. Resolution paths represent trajectories from initial tensions to solutions (two phases) and span from t_1 to t_2 . In tension loops, tensions persist, or new tensions emerge even after suggesting solutions. The tension loops cover three or four phases, depending on whether they span from t_1 to t_3 , or from t_1 to t_4 . Of the 17 trajectories identified in our study, we pinpoint seven trajectories outlining resolution paths, and ten

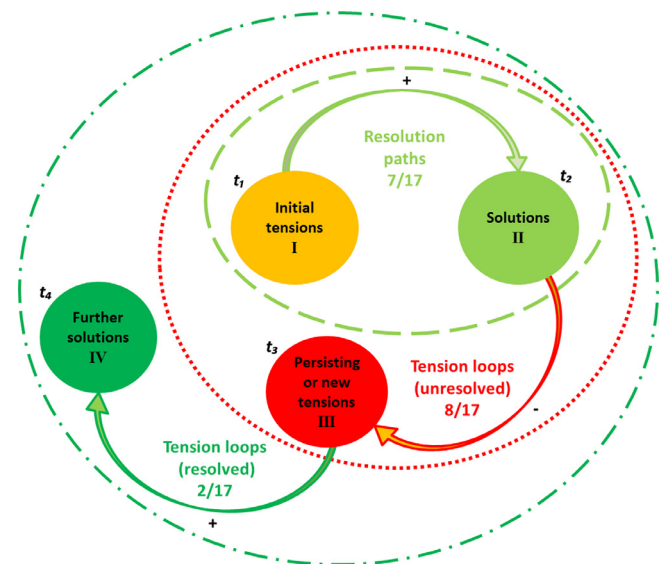


Fig. 1. Trajectories from initial tensions to solutions (or to further tensions) in OI projects.

trajectories exhibiting tension loops. Although in two cases the tension loops are solved by further solutions (IV) – dubbed as *resolved tension loops* - a majority of tension loops (eight out of ten) remain unresolved (*unresolved tension loops*).

Fig. 1 illustrates the four phases and the different types of trajectories. The four phases of the trajectories, numbered in roman numerals

from I to IV, are illustrated in the figure as round filled shapes in the colors yellow, light green, red and green, respectively. The trajectories between the phases are marked by curvilinear arrows. When the paths go from tensions (I or III) to solutions (II or IV) we mark the arrow between such phases with a '+' to show that the tensions are being solved. Similarly, when the trajectories go from solutions to further tensions, i.e. from phase II to III, we mark the arrow between these phases with a '-' to highlight that tensions persist. The phases and arrows included in each type of trajectory are marked by different color circular dotted lines: resolution paths are marked by a light green line, tension loops (unresolved) are delineated by a red line, and tension loops resolved are marked by a green line.

We link phases I and III to difficulties of either not creating or not capturing value, or even both, thus suggesting an imbalance between value creation and capture. In phases II and IV the proposed solutions generally attempt to restore the balance.

We further pinpoint broader and narrower categories for tensions and solutions. The broader categories of tensions relate to *asymmetry, IP and legal shortcomings* (which can also mean going to extremes) and *partner-specific* tensions. They have corresponding categories of solutions, i.e. solutions for *levelling* the asymmetries, solutions related to *appropriability measures*, and *partner selection* solutions. These broad categories of tensions and solutions have subcategories and there are a few narrower categories of tensions and solutions, which only include one subcategory each. It should also be noted that not all categories of tensions have corresponding categories of solutions. The categories and subcategories are highlighted in the tables by italic text, and categories are further capitalized to distinguish from subcategories. We also map the categories and subcategories of tensions and solutions in Fig. 2 in Appendix 1, thus creating a map of trajectories for balancing value creation and capture.

In the following, we further detail and contrast the 17 examples of resolution paths and tension loops. Tables 2–4 show the different types of trajectories in our data accompanied by relevant quotes.

4.2. Resolution paths

Table 2 shows the seven trajectories from tensions to solutions labeled as resolution paths. Three of these seven paths encompass initial asymmetry tensions (Paths 1, 2 and 3), which are resolved with solutions of levelling asymmetries. A fourth resolution path with compound initial tensions of asymmetry (Path 5) is also resolved with the use of levelling solutions. Specifically, Paths 1 and 5 both originate from the difficulties of the case companies' partners to capture value, which ultimately affected all parties involved in the collaborations. The initial tensions in the two paths relate to *asymmetries of legal and IP management resources* (Path 1) and to *unprotected IP* combined with *excessive revealing* (Path 5). As for solutions, in Path 1 Company C levels the asymmetry by *simplifying contracts*, while in Path 5 Company F outlines how *sharing* own technological progress aids trust building with start-up partners. Path 2 entails a different type of asymmetry, namely *uneven distribution of IP ownership*, which causes Company E to fail to capture sufficient value from an OI project. The levelling solution is to co-own the IP with OI partners. Path 3 also underlines tensions related to asymmetry – this time *asymmetry of (financial) resources* – highlighted by Expert 5. Such tensions would render a start-up helpless in an infringement lawsuit with a large firm, even though the start-up protected its invention with formal IP mechanisms. A solution to level this type of asymmetry is endorsed by both Expert 5 and Expert 6: a third party (larger company) *acquires* the start-up, thus providing it resources to continue the legal battle.

Two additional resolutions paths entail tensions of IP and legal shortcomings and corresponding solutions related to appropriability measures (Paths 4 and 6). In Path 4, *(excessive) revealing* represents the initial tension; this entails sharing more information than necessary about an invention with a partner. Carefully selecting the parts that need to be revealed, i.e. *selective revealing*, would maximize value cap-

ture and is therefore suggested as an effective solution here. In Path 6, the challenges related to *territorial nature of formal IP protection* highlight difficulties to capture value. Possible solutions relate to *extending the territorial coverage of IP protection* by choosing a Patent Cooperation Treaty (PCT) route instead of applying for a patent in one single territory (Path 6).

Finally, in Path 7, initial tensions relate to IP and legal shortcomings, in particular contractual limitations (*incomplete contracts*), which could be circumvented by selecting partners from another industry that possess *different (asymmetric) knowledge bases*. Such partners would be non-competitors and thus the risks posed by incomplete contracts would be rendered inconsequential.

4.3. Tension loops

Table 3 shows the eight *unresolved tension loops* emerging from our data. As in Table 2, the loops in Table 3 are derived from the interviewees' accounts of different situations and different types of tensions and solutions are illustrated through quotes. While in Table 2 we observed one example of compound tensions in Path 5, in Table 3 all eight tension loops entail compound tensions and sometimes even compound solutions (Loops 2 and 5). The compound tensions emerge either as pairs of different types of tensions in the initial phase (I) or as distinct kinds of tensions in the phases I and III respectively.

Loop 1 highlights a combination of *knowledge boundaries* and *temporal tensions*, which persist in phase III, after solutions have been enforced. Specifically, Company A experiences difficulties separating new from prior knowledge in fast-track OI projects with incremental innovation. The solution adopted for this conundrum is an appropriability measure, i.e. *increased involvement of the IP department* in such projects – the employees in the IP department are experts in recognizing what might be patentable knowledge and in distinguishing novel IP from prior art. However, due to the brief time available to sort these types of knowledge in fast-track projects – and particularly in incremental innovation – the tensions persist in Loop 1.

Company A confronts a further unresolved loop (Loop 2) where partner-specific tensions are illustrated. Specifically, the issues of *opportunism* and *knowledge leakage* to second-order competitors emerge: after Company A shares innovative solutions with clients, the clients would further share these with other companies (suppliers) in order to identify the most advantageous manufacturing price. Efforts in terms of *increasing awareness about IP, involving the IP department more* in OI projects, and *improving contractual agreements* are only effective to a limited extent. Partner-specific tensions of *interdependency* occur because Company A needs to stay open and share potential innovative solutions with clients in order to 'win work'.

Loop 3 highlights initial tensions of opportunism (I), which persist in phase III as well. After solutions of *milestone contracts* are enforced, another type of tension related to *incomplete contracts* emerges alongside the persisting tension of opportunism.

IP and legal shortcomings in contracts are pinpointed in Loop 4, yet this time relating to *not using the right contracts* in an OI project. Expert 3 describes a case where receiving a disclosure from a small company without having the right agreements in place opened up the possibility of a lawsuit. The enforced solutions to prevent such occurrences in the future entail *partly closing the innovation process*. Nevertheless, a more closed approach underlines new tensions of *overprotectiveness* and is likely to diminish opportunities to create value.

IP and legal shortcomings-related tensions further pinpoint the *wrong department* (at Company C) *handling the contract for an OI project*, thus leading to missed opportunities to capture value. Company C adopts a solution linked to appropriability measures, i.e. creating a *cross-functional task force (team)* that would deal with such contracts and conduct a 'campaign' to *raise IP awareness*. However, tensions may persist when attempting to *raise IP awareness* at all levels of the firm (e.g. shop floor level).

Table 2
Resolution paths – Trajectories from initial tensions to solutions.

Path	Initial tensions (I)	Solutions (II)
Path 1	Partners' difficulty to capture value due to <i>Asymmetry of legal and IP management resources</i> eventually leads to failure to create value for all partners	Partners' value capture potential enhanced by <i>Levelling the asymmetries through simplifying contracts</i>
Quotes	<i>The start-ups are too small to compete with our legal power. They lack legal and IP management resources. (...) We are losing opportunities: in some cases, the start-ups do not want to work with us because we are too complicated.</i> (Head of IP department, Company C)	<i>We need to reduce formalism in our contracting.</i> (Head of IP department, Company C)
Path 2	Insufficient value capture due to <i>Asymmetry of legal and IP management resources</i> with regard to <i>uneven distribution of IP ownership</i>	Increased focus on value capture through <i>Levelling (IP co-ownership)</i>
Quotes	<i>We invested a lot in this but we did not get what we wanted [out of it]. We agreed [with our partners] to share information but that each partner would own separate IP rights for what they developed.</i> (Head of Business Unit, Company E)	<i>We should have gone in [the partnership] as IP co-owners because we influenced the product development. Our strategy has changed after this project and we are more flexible. If there is an innovation that is important to us, we make sure to have a share of the IP ownership.</i> (Head of Business Unit, Company E)
Path 3	Difficulties to capture value due to <i>Asymmetry in financial resources</i>	Enhanced value capture potential through <i>acquisition</i> by a large firm, thus <i>Levelling the asymmetry of resources</i>
Quotes	<i>A start-up called P shared ideas with a large group, M. The discussions ended up nowhere. Five-six months later, P discovered that M was using the technology that P had disclosed to M. Company P. had IP protection, so they started a lawsuit against M. [However,] because M. had deep pockets, they took the approach of just squeezing the start-up so that eventually the start-up would give up.</i> (Expert 5)	<i>The pattern was disrupted because P was acquired by R, which provided P with the capital to continue litigation. And, in the end, M was forced to settle the case and pay several million dollars to the start-up P.</i> (Expert 5) <i>What the smaller company could've done is get another big company to join in with them to have more power.</i> (Expert 6)
Path 4	Possible difficulties to capture value due to <i>IP and legal shortcomings</i> related to <i>excessive revealing</i>	<i>Appropriability measures</i> in terms of <i>selective revealing</i> maximize value capture
Quotes	<i>Let's say I'm looking for a new protein and I'm looking for a partner to develop this with. If the partner were to provide me with the chemical formula and the synthesis to the protein, then that information is typically confidential. I am initially not interested in how they make the solution, but in the characteristics of the solution.</i> (Expert 1)	<i>If you split solution information, there are different bits and pieces. [...] There is something [here] related to the characteristics of the solution: what its impact is, what does it do. Not how it is produced but how it works. [...] There is no need to provide all that information [related to solution information] to a potential partner.</i> (Expert 1)
Path 5	Partners' difficulty to capture value due to <i>IP and legal shortcomings</i> in terms of <i>unprotected IP and excessive revealing</i>	Partners' value capture potential enhanced through <i>Levelling solutions</i> related to <i>sharing technological status quo</i>
Quotes	<i>When a large company invites small companies or entrepreneurs in, one has to be a bit careful that if they pitch an idea they also have it protected [via a patent].</i> (Head of Strategic Research, Company F)	<i>We told [the small company]: 'This is what we have tested, and this is what we already know'. So, without having required that they have a patent beforehand, we put up a sort of platform for this collaboration.</i> (Head of Strategic Research, Company F)
Path 6	Difficulties to capture value due to <i>IP and legal shortcomings</i> with regard to <i>territorial limitations</i> of formal IP protection	Enhancing value capture with <i>Appropriability measures</i> , i.e. <i>extending the territorial coverage</i> of the formal IP protection
Quotes	<i>From a big company perspective, if a start-up has developed a technology but it is only patented in one country and the priority year has passed, then it is not an asset for the big company anymore. It is still a relevant technology, but it has become free to use outside this specific country. So, the big company could either use the patent outside that country for free or use the patent as prior art and apply for a new patent.</i> (Expert 1)	<i>Start-ups don't have the knowledge on this, they don't even know what a PCT [Patent Cooperation Treaty] route is, or that they can extend a national patent application via the PCT route for relatively little money, but that doing so would buy them another 24 months before they have to decide in what countries to register the patent. This in turn provides them enough time to look for a partner.</i> (Expert 1)
Path 7	Possible risks to not capture value due to <i>IP and legal shortcomings</i> with regard to <i>incomplete contracts</i>	<i>Selecting partners with different knowledge bases</i>
Quotes	<i>In one of the cases [when we experienced tensions] we needed a partner from the textiles branch. (...) Laws and rules are very good, but they are not something to bank upon.</i> (Industrial Engineering Manager, Company D)	<i>In this case it was rather easy to differentiate between the knowledge we [each] entered in the project, because we each had superior key competences in distinct areas. So the risk that they would contact our competitors and start working with them was low. (...) I would say that tensions decrease dramatically if the different partners have different core competences. It is not that way with competitors.</i> (Industrial Engineering Manager, Company D)

Loop 6 entails further IP and legal shortcomings tensions related to disclosing unprotected IP (codified knowledge): Company B, a start-up, contemplates disclosing the IP to an OI partner - a large firm; the proposed solution, an appropriability measure, would be applying for a *cheaper type of patent* available in the US; new tensions would surface though, since the solutions does not provide IP protection in other territories, thus highlighting tensions of IP territoriality.

Loop 7 highlights tensions of asymmetry of *organizational culture* and IP and legal resources. Company C and their partner, a large research institute are different both organizationally and in terms of IP department strength, which leads to difficulties in agreeing on contractual terms and creating value. Potential solutions might encompass *framework agreements*, which would facilitate negotiations with the research institute;

however, these are overcome by 'unbridgeable (cultural) differences' between the two partners, hence the tensions persist.

Loop 8 underlines tensions referring to IP and legal shortcomings in the form of incomplete contracts that do not protect all partners from potential misappropriation. Company D and Expert 6 suggest *compromising by aligning interests* with partners as a possible solution. However, in case of severe opportunism from partners, this solution would not resolve the initial tensions, thus making tensions persist.

Finally, [Table 4](#) highlights the two *resolved tension loops* in our data. In Loop 9, Company A's managers stress the lack of awareness about IP among employees who actively participated in OI projects. This caused challenges to capture value from these projects for Company A. The solution enforced here was to increase the involvement of the IP de-

Table 3
Unresolved tension loops.

Loops	Initial tensions (I)	Solutions (II)	Persisting and/or new tensions (III)
Loop 1	Difficulties to capture value due to knowledge boundaries- and temporal tensions	Enhanced value capture through Appropriability measures of increased involvement of IP department in OI projects	Difficulties to capture value persist due to knowledge boundaries- and temporal tensions
Quotes	<i>We are often in incremental innovation [in these fast-track projects].</i> (Head of IP department, Company A)	<i>Our IP department has been much more active the last years than it has been previously. There has been much more of an integration of it into the projects.</i> (Project Engineering Manager, Company A)	<i>When we come up with a new solution for a client it's often very close to existing solutions. That makes this exercise of identifying innovation in real time very difficult.</i> (Head of IP department, Company A)
Loop 2	Difficulties to capture value because of IP shortcomings related to knowledge leakage to second-order competitors and Partner-specific tensions concerning opportunism	Enhanced value capture through Appropriability measures of increased involvement of IP department, raising staff IP awareness and improving contracts	Persisting risks of knowledge leakage to second-order competitors due to Partner-specific tensions of interdependency
Quotes	<i>We have seen our conceptual ideas having been taken from us at little cost for the client, for them to pass on then to another third party</i> (Global Engineering Manager, Company A) <i>It (happened) in the past and it still occurs: the clients will take solutions we just discussed and bring them to other companies to 'open the competition', to solve their problem.</i> (Head of IP department, Company A)	<i>I think we're becoming more and more aware of these issues and it's true that our IP department has been much more active the last years than it has been previously.</i> (Project Engineering Manager, Company A) <i>It is a major change that is occurring. It occurs through raising awareness through trainings, through increasing the template non-disclosure agreements and contracts and raising contractual and confidentiality awareness of engineers, especially the ones working those short track projects. That is something that we are currently in the middle of.</i> (Head of IP department, Company A)	<i>I think, we're in a position at the moment, where we are in danger of not paying attention to the IP issue at all, in our keeness to be involved in the process with our client. Perhaps we are not as guarded as we might be, because if we do not enter the conversation we are not part of the discussion, and then we certainly are not going to win the work.</i> (Global Engineering Manager, Company A)
Loop 3	False pretense to create value (Partner-specific tensions of opportunism) diminishes partners' potential of capturing value	Partners' value capture potential improved by using Appropriability measures of milestones in contracts	Severe opportunism tensions persist and may further hinder value creation and capture, highlighting IP shortcomings of incomplete contracts
Quotes	<i>Some solution providers suspect that clients do that. (...) They [clients] don't really have an interest in making a deal, they just want to see what's out there – which we try to fight hard.</i> (Expert 2)	<i>One of the things I have seen clients do is to come up with 'milestone' contracts.</i> (Expert 2) <i>Milestones are actually very useful and can be very important. A regular contract does not deal with the future at all [milestones do].</i> (Expert 6)	<i>But, even with milestones, if the people are very obstinent and ignore everything [in the contract] there is nothing to be done.</i> (Expert 6)
Loop 4	Overlooking value capture by not using the right contractual agreements (IP and legal shortcomings)	Enhanced value capture through Partner selection solutions of '(partly) closing OI	Diminished value creation potential due to overprotectiveness (IP excess tensions)
Quotes	<i>On one occasion we did not insist on the right agreements and this lead us to receiving a disclosure, which enabled a small company to sue us. We settled out of court in that case, but we had to settle.</i> (Expert 3)	<i>We've had several occasions where companies had come to us with ideas that they claimed were absolutely ground-breaking and we find out that we have actually had the idea ourselves in the company, for various reasons not taking it forward. That has certainly happened a lot. So we tend not to encourage unsolicited approaches. [...] We try to put a bit of a wall up.</i> (Expert 3)	<i>It [being very secretive and protective about IP] stops you from being able to collaborate with companies of similar size or with smaller companies.</i> (Expert 4)
Loop 5	Difficulties to capture value because of IP and legal shortcomings in terms of the wrong department handling the OI contract	Enhanced value capture efforts by introducing Appropriability measures of cross-functional teams and raising awareness about IP	Difficulties to capture value persist because of further tensions related to IP and legal shortcomings in the form of difficulties to raise IP awareness at all firm levels
Quotes	<i>Nobody (of those representing our company) understood the contract and that is why we have a big problem now. This wouldn't have happened if the new concept (of cross-functional teams) were in place.</i> (Head of IP department, Company C)	<i>I think that we need to adapt a little bit. That is only possible if we combine responsibilities from several departments.</i> (Head of IP department, Company C) <i>Different departments have individual expertise. So, 90% of the time, the system works, probably quite effectively. But it falls down when you have these cross-functional issues.</i> (Expert 6)	<i>The biggest challenge then is to make the people aware on shop floor level that they should behave in a certain way. That is the main challenge. So the awareness campaign – as I call it –is crucial to make this whole concept successful.</i> (Head of IP department, Company C)

(continued on next page)

Table 3 (continued)

Loops	Initial tensions (I)	Solutions (II)	Persisting and/or new tensions (III)
Loop 6	Difficulties to capture value (<i>IP and legal shortcomings</i>) when disclosing unprotected IP	Enhancing value capture with <i>Appropriability measures</i> , i.e. <i>applying for cheaper formal IP</i>	Difficulties to capture value persist due to <i>IP and legal shortcomings</i> linked to <i>IP territoriality</i>
Quotes	<i>Any engineer would understand how it works, so there is no point in trying to keep it secret. We have to introduce it fast into the market. [...] Before pitching an idea to a large company, we ought to have a patent on this.</i> (Co-founder, Company B)	<i>We have talked about applying for a provisional patent in the US – it is a lot cheaper because it is a temporary patent.</i> (Co-founder, Company B)	<i>Even if we apply for a provisional patent in the US, we still do not have [IP] protection in Sweden or Germany.</i> (Co-founder, Company B)
Loop 7	Difficulties to create value due to <i>Asymmetry tensions</i> related to <i>legal resources and organizational culture</i>	Enhancing value creation by applying <i>Appropriability measures</i> in the form of <i>framework agreements</i>	Difficulties to create value persist due to <i>persisting Asymmetry tensions</i>
Quotes	<i>Our partners (a research institute) are very strong [compared to our company]in terms of IP and legal department (...) and there is a difference in [organizational] culture and goals.</i> (Head of IP department, Company C)	<i>The framework agreement would be very good because then we could just refer to it when collaborating with them [on different OI projects].</i> (Head of IP department, Company C)	<i>It is still not done and there are unbridgeable differences.</i> (Head of IP department, Company C)
Loop 8	Difficulties to capture value due to <i>IP and legal shortcomings</i> in the form of <i>incomplete contracts</i>	Improving value capture by applying <i>Levelling solutions</i> , i.e. <i>compromising with partners by aligning interests</i>	Possible difficulties to capture value if partners choose to act <i>opportunistically</i>
Quotes Loop 8	<i>You can get situations where two companies sign an NDA but some months later one of the companies finds that a patent application has been filed using the shared information.</i> (Expert 6)	<i>So we thought that it would be better to make sure that our partners are happy with what they contribute and with what they get out of the collaboration - so that they don't find a reason to work with our competitors.</i> (Industrial Engineering Manager, Company D) <i>So, sometimes it is a compromise, an arrangement that one comes to in the end.</i> (Expert 6)	<i>If our partner had chosen to do this [work with our competitors], it would have been easy for them to sell the IP to one of our competitors. From a legal point of view, they could have done that and we wouldn't have been able to do anything about it.</i> (Industrial Engineering Manager, Company D)

Table 4
Tension loops solved.

Loops	Initial tensions (I)	Solutions (II)	Persisting and/or new tensions (III)	Further solutions (IV)
Loop 9	Difficulties to capture value due to <i>lack of awareness about IP protection matters (IP shortcomings)</i>	Enhanced value capture by <i>raising IP awareness and improving communication with IP department (Appropriability measures)</i>	Difficulties to capture value persist due to the <i>small size of the IP department (Asymmetry)</i>	Value capture efforts balanced by <i>industry-specific project conditions</i> , which limit seasonal work for the IP department
Quotes	<i>A lot of emails used to come in after meetings with partners. Colleagues were asking how to protect ideas after having already described them to our partners. I explained that it was too late.</i> (...) (Head of IP department, Company A)	<i>Now it is rare: in the majority of cases people tell me one week or several days before the meeting and I just tell what to disclose and what to withhold.</i> (Head of IP department, Company A) <i>Our IP department has been much more active the last years. There has been much more of an integration of it into the projects.</i> (Project Engineering Manager, Company A)	<i>We don't really have a legal department, whereas our competitors have a massive legal department, and sometimes they are successful simply because of that.</i> (Project Engineering Manager, Company A) <i>It is not easy being a small IP team</i> (Head of IP department, Company A)	<i>It is working well [even with a small IP department] because the questions are not coming from everywhere at the same time. Doing projects off-shore corresponds to weather so it is not [done] the same time of the year [all around the world].</i> (Head of IP department, Company A)
Loop 10	Difficulties to capture value due to <i>Legal shortcomings</i> regarding <i>incomplete contracts</i>	Enhanced value capture by <i>Leveling solutions of compromise</i> ()	Difficulties to capture value persist due to <i>temporal tensions</i>	Value capture potential balanced by <i>applying Partner selection solutions of checking partners' reputation</i>
Quotes	<i>I notice that a lot of folks really want to do everything in legal documents – that doesn't really help you, if things go wrong.</i> (Expert 4)	<i>I rely more on the people, on trying to align their interests, and on building and maintaining trust.</i> (Expert 4)	<i>If there is no time to build trust...</i> (Expert 4)	<i>...second best is to verify with other people that have worked with your partner and find out how they behave.</i> (Expert 4)

partment in the OI projects and to raise the employees' awareness of IP issues. A new tension emerges, as the limited resources of the IP department are difficult to split between a large group as Company A, with multiple projects all around the world. The further solution here relates to *industry-specific conditions* of the oil and gas industry, i.e. projects occurring at different times of the year across the globe (specifically due to off-shore conditions). This makes the targeted involvement of the IP

department possible in most of the OI projects, despite the limited resources of the company's IP department.

In Loop 10, initial tensions with regard to legal shortcomings of contract limitations are highlighted, yet the initially suggested solution of building trust and aligning interests between partners highlights new temporal tensions, as building trust takes time. The further solution suggested in Loop 10 relates to *checking potential partners' reputation* via

third parties. This might circumvent the lack of time to build trust and aid in identifying partners with similar interests and goals.

In the following we discuss our findings concerning resolution paths and tension loops in relation to previous studies. We highlight categories that emerge from our analysis and distinguish between effective and ineffective solutions, thus formulating avenues for future research. We conclude by summarizing our findings and discussing implications for researchers and managers.

5. Discussion

5.1. Initial and persisting tensions

One of the broader categories of tensions pinpointed by our analysis is that of asymmetry. Partially dictated by the input needed for the innovation, and partially promoted by the opportunities present in the surrounding innovation ecosystems, different types of asymmetric relationships are formed to generate genuinely new combinations of knowledge (e.g., De Groote & Backmann, 2020; Kalaignanam et al., 2007; Oughton et al., 2013). Asymmetry of resources, for example, does not always translate into complementarities, but it may indicate restrictions in capabilities to balance value creation and capture. Tensions of asymmetry in our data often stem from resources. Small firms typically require resources from larger, established firms in order to create value. Yet at the same time the resources of the smaller companies are put at risk (Diestre & Rajagopalan, 2012). As a relevant dimension in this, the asymmetry of IP and legal resources is most common in our findings (present in Paths 1, 2 and Loops 7 and 9), and delineates imbalances of legal and IP management resources between partners in OI projects. Path 2 refers to a slightly particular type of IP asymmetry, one that is not as much related to resources, but rather to how the IP ownership was unevenly shared between partners. In prior research, Rayna and Striukova (2010) refer to such imbalances between large and small firms and highlight value capture risks for smaller firms. While this is typically more stressful for small firms, it may also occur between large firms. In Loops 7 and 9, asymmetries of IP and legal resources are highlighted between Company C and a research institute, as well as between Company A and its competitors - all large firms. Additionally, in Loop 7, another source of asymmetry is organizational cultures. Conflicting incentives between firms and academic institutions have been emphasized in prior studies: while the former are motivated by monetary incentives and a limited willingness to disclose knowledge to competitors, the latter are steered by non-monetary incentives and strong incentives to publish findings (Perkmann & Schildt, 2015). In Path 3, we find a third type of asymmetry, i.e. asymmetry of financial resources. The example provided in Path 3 is one where a start-up that has IP protection for an invention sues their partner for infringement. Despite the legal protection, the financial resources of the partner would be no match for the start-up's resources to fight a legal battle, which stresses again asymmetries between large companies and small, young companies (see e.g. Diestre & Rajagopalan, 2012; Hallen et al., 2014). While financial, IP and legal resources asymmetries seem to be resolvable both in collaborations between small and large, as well as between large firms (Paths 1,2, 3 and Loop 9), when asymmetries of organizational culture are present and combined with IP and legal asymmetries (Loop 7), tensions persist.

A further broader category of tensions is that of partner-specific tensions. These highlight interdependency and opportunism. The latter emerges both as initial and persisting tension and has been emphasized as source of tensions in OI in prior studies (e.g. Foege et al., 2019). Another broad category of tensions in our study is dubbed IP and legal shortcomings (or excesses). It relates to appropriability deficiencies, such as unprotected IP, lack of IP awareness among staff, contractual limitations of failure to use proper contracts when required, or excesses, e.g. overprotectiveness of IP. The latter has been highlighted in prior studies (e.g. Frishammar et al., 2015). In Path 5, the theme of unprotected IP is combined with (excessive) revealing (see e.g. Giannopoulou

et al., 2011) when underlining the risks of pitching an unprotected idea to a partner. The theme of (excessive) revealing recurs also in Path 4, in a situation similar to that in Path 5, and also as initial tension in Loop 2, where partners would leak ideas to second-order competitors (Hernandez et al., 2015) in search for lower production prices.

Further narrower categories include temporal tensions and tensions related to knowledge boundaries: the former are present in both Loop 1 and 10, while the latter is also present in Loop 1, thus building compound tensions. This particular combination of tensions in Loop 1 underlines difficulties to separate existing and newly created incremental innovation in fast-paced OI projects. Time has previously been introduced as a dimension in projects (Söderlund, 2002; 2012) yet has seldom been linked to tensions of value creation and capture. According to recent studies, time may have a dual role with regard to tensions of value creation and value capture, i.e. it would yield both positive and negative outcomes depending on the context (Niesten & Stefan, 2019).

5.2. Effective solutions

The effective solutions for tensions in OI projects are highlighted in our study in Tables 2 and 4. While many of the previously introduced categories, which relate to the initial and persisting tensions, also have solutions from corresponding categories- e.g. asymmetry tensions have solutions of levelling - others have solutions that are less obvious.

In Table 2, all seven resolution paths have effective solutions. Several of the initial tensions in the paths underline asymmetries, while the others highlight issues of IP and legal shortcomings, and excessive revealing or excessive IP protection (over-protection). For the subcategories related to asymmetry, we pinpoint several solutions that involve levelling as the means to address the asymmetries. These solutions are often effective, as can be observed in Paths 1, 2, 3 and 5. It appears that adjustment is a key aspect that project management can provide so as to reach enduring solutions. This can involve loosening the focal firm's initial approach towards IP protection and governance of the collaboration. Levelling solutions appear to often address asymmetries between small and large firms (e.g. Diestre & Rajagopalan, 2012), as in Paths 1, 3 or 5. It is noteworthy that the ultimate goal of these solutions is to build trust, either via making contracts more accessible to small companies, or by sharing details about proprietary IP. This kind of approach that does not highlight self-serving needs but takes the other party (or parties) into account, is endorsed in prior studies: building of trust is linked to the role of individuals in successful or unsuccessful value capture (Olander et al., 2015). What is rather distinctive in our findings is that the asymmetries are compensated by the large company in each of these OI projects, i.e. the company with more bargaining power. The firms that are initially directly affected by said asymmetries, i.e. start-ups, seem not to be able to level the asymmetries and shortcomings on their own. We argue that this further points to a prerequisite that the partners in an OI project be willing to smoothen obstacles for one another. Levelling solutions further include mergers and acquisitions (M&A) to compensate financial resources (Path 3), or IP co-ownership with OI project partners (Path 2). The latter has been associated with higher market value, especially in the case of joint patenting between industry and universities (Belderbos et al., 2014), yet the same authors find that co-patents receive fewer self-citations, which could point to difficulties in future development of co-owned technologies. However, this could also suggest that co-owned patents are less valuable on average, and that, in turn, very valuable technology companies may not arrive at that type of solution.

Effective solutions related to appropriability measures entail selective revealing and extended IP territorial coverage. In Path 4, tensions linked to excessive revealing are alleviated by the former, i.e. selective revealing (Alexy et al., 2013; Henkel, 2006), which delineates the knowledge that is necessary to share to make partners interested, and at the same time maintains secret other knowledge bits that are irrelevant to the negotiation with partners. At the same time, tacitness of knowl-

edge and the stage of development may influence both the incidence and the value of selective disclosure. For instance, [Katila and Mang \(2003\)](#) suggest that early development phases often involve highly tacit knowledge, which is difficult to articulate or separate. This may cause misunderstanding or confusion if shared with external parties (see [Katila & Mang, 2003](#)). Hence, we argue that the solution proposed by Expert 1, which is selective revealing, would most likely work at later stages of the technology development. Extended IP territorial coverage appears in Path 6 as applying via the PCT route instead of a national route for a patent ([Erstling & Boutillon, 2005](#)). According to Expert 1, this allows for more time to search for an OI partner, while also having more options in terms of territories where the invention could be protected and utilized.

Another effective solution, described in Path 7, relates to partner selection, i.e. working with non-competing partners with highly asymmetric knowledge bases. This is in line with prior studies that highlight how different knowledge bases of different actors could be combined to innovate (see e.g. [Asheim et al., 2011](#); [Contractor & Ra, 2002](#)). In the case of competitors, technological bases are rather similar and therefore IP protection is highly important in competition settings, even at the cost of diminished creation ([Bengtsson & Kock, 2000; 2014](#); [Dagnino, 2009](#); [Ritala & Hurmelinna-Laukkanen, 2013](#)). In contrast, collaborating in OI with partners with highly different technology bases presents fewer risks of leakage and misappropriation.

Further effective solutions are shown in Loops 9 and 10, presented in [Table 4](#). A common characteristic of these two loops is that while the initial tensions are resolved by the first round of solutions, new tensions occur after these solutions have been enforced. Luckily, the second wave of tensions has further effective solutions. The further solution in Loop 9 links to industry-specific conditions, which in industries such as oil and gas could alleviate asymmetry tensions related to limited IP resources. Context-specific solutions concerning appropriability have been emphasized by e.g. [Neuhäusler \(2012\)](#). In Loop 10, initial tensions are solved by compromise, unless conditioned by time constraints. By applying partner selection solutions and checking potential partners' reputation, the temporal tensions that may occur could be alleviated.

5.3. Ineffective solutions

Despite suggested solutions, some tensions persist, thus leading to unresolved tension loops shown in [Table 3](#). As highlighted in the previous sections, the majority of tension loops emerging from our data remain unresolved (except the two resolved loops presented in [Table 4](#)). We believe that this is due to the notable complexity of value creation and appropriation tensions in OI ([Laursen & Salter, 2014](#)) highlighted in our study by compound tensions, and the generally high risks of misappropriation in such contexts ([Lorenz & Veer, 2019](#)).

We notice that although the initial and persisting (or new) tensions in the unresolved tension loops stem from various categories that are most often bundled (compound tensions), the majority of solutions that fail to alleviate tensions relate to appropriability measures – except for Loop 8, where some of the levelling solutions fall short in producing desired project outcomes. A possible explanation to the propensity of appropriability measures enforced in tension loops is that since most unresolved tension loops stem from difficulties to capture value, solutions related to appropriability are closest to what might appear to be increased value capture efforts. However, in some cases appropriability measures are applied to tensions of asymmetry or compound partner-specific and IP and legal shortcomings tensions. Thus, while not addressing the essence of the complex tension bundles per se (by e.g. addressing asymmetry tensions with levelling solutions), the managers attempt to restore the balance between creating and capturing value by employing appropriability measures. For example, in Loop 1, the applied solution of involving the IP department to tackle fuzzy knowledge boundaries in fast-paced projects only resolves part of the tensions, because in such OI projects the time is often too short even

for IP experts to delineate the knowledge boundaries between prior art and the newly created knowledge. An additional solution would have been required in this case to address the time-issues in said projects. Such solution might, for instance, relate to improving contractual terms that allow more time for specific actions, or to developing internal organizational routines that would help alleviate the time-pressures.

In the four loops where the tensions relate to IP and legal shortcomings (Loops 2, 4, 5 and 6), we observe that even though the initial IP-related tensions are (partly) resolved, new tensions emerge. These persisting tensions indicate that resolving appropriability issues is challenging, and moving the basis of appropriation quickly may not be possible due to contextual factors.

As for the loops where the suggested solutions were not related to appropriability measures, in Loop 4 we see how prior experiences with sharing IP could render actors overly protective, and thus less open to external sources of innovation. This finding is in line with the study by [Lorenz and Veer \(2019\)](#) who point out decreased openness after misappropriation has occurred. While [Lorenz and Veer \(2019\)](#) highlight the diminished willingness to collaborate in the absence of formal IP protection, our data suggest that the use of formal IP protection mechanisms (e.g. patents) is not primarily linked to the decreased openness. Instead, in Loop 4, it is legal shortcomings in the form of incomplete contracts that created the opportunity for Expert 3's company to be falsely accused of misappropriating an idea. Moreover, it appears that the degree of openness plays a particular role in the balancing of value creation and capture. In our study, we find tensions associated with the necessity to be open also in the situations characterized by the need to be more closed because of leakage to second-order competitors. Likewise, we find ineffective solutions in the form of partner selection, specifically related to partly closing OI, which diminishes the opportunities to create value with external actors. It seems thus that the degree of openness would require careful calibration. This relates to recent studies that highlight open-closed dynamics ([Appleyard & Chesbrough, 2017](#)) as well as the IP disassembly problem ([Granstrand & Holgersson, 2014](#)). In Loop 8, as in Loop 3 we find that neither appropriability improvements in the form of milestones, nor compromise work as effective solutions for severe opportunism ([Bhattacharya et al., 2015](#); [Hagedoorn & Heslen, 2007](#); [Kloyer & Scholderer, 2012](#)).

5.4. Future research avenues

The above discussion gives start to identifying multiple areas where further research could be carried out. First, while appropriability mechanisms – particularly formal ones – have been endorsed in OI endeavors by scholars, more research is needed concerning the imperfect nature of such mechanisms, e.g. the territorial character of formal IP rights ([Trimble, 2014](#)) and the costs related to extending IP territoriality. Likewise, it would be valuable to further examine the potential threshold levels of adequacy of protection in OI projects, and how such projects could be taken forward if one of the partners chose to act opportunistically, breach contracts and misappropriate IP. This also raises issues of ethics and fairness as a second relevant area of future research. Although such topics have been tackled by prior studies on crowdsourcing ([Faullant et al., 2017](#); [Franke et al., 2013](#)), we call for scholars to further investigate issues of fairness in OI projects.

Moreover, while certain solutions seem to be effective for some tensions, in other situations, challenges persist. Such an example would be the role of compromise, entailing the alignment of partners' interests, as either effective solution (Loop 10) or as ineffective solution (Loop 8). This finding could point to the previously highlighted dual roles of specific factors in interorganizational relationships ([Niesten & Stefan, 2019](#)). It would therefore be highly relevant to advance our understanding as to what makes specific approaches both effective and ineffective. We suspect that this relates not only to contextual issues, but also to temporal aspects.

In fact, future studies might consider adopting a dynamic perspective and taking a closer look at temporal elements (see Bahemia et al., 2018). The importance of time-frames has been emphasized in project management literature (e.g., Söderlund, 2002; 2012), but in OI literature these have received less attention. Managerial challenges related to time constraints are quite visible in our data, and it cannot be overlooked that the phase of the OI project and related issues, such as evolving familiarity of the involved actors with each other, might bear importance.

Yet another issue that requires further research concerns the role that intermediaries might play in OI projects. It remains unclear, which factors determine a successful involvement of intermediaries in OI projects (Foegen et al., 2019; Pollok, Lüttgens, & Piller, 2019), if their involvement is relevant in alleviating tensions related to opportunistic behavior. Likewise, it would be important to know what might cause intermediaries to fail in tackling such tensions – a situation shown in Loop 3 in our data.

Relatedly, future research might also investigate indirect effects that value creation-value capture tensions could possibly have on other parties that are to some extent dependent on one of the partners implicated in the conflicting OI project. While we do not focus on these issues in our work, we acknowledge that such indirect connections could be relevant in contexts where multiple actors are involved, such as the case of mega-projects (e.g., Brady & Davies, 2014). Here, it would be of further interest to investigate whether specific solutions would secure progress of the project despite local tensions.

Finally, our study calls for more research on persisting tensions. While our findings verify that persisting tensions related to value creation and capture indeed emerge in OI projects, it is not obvious whether the persistence of tensions is a consequence of the complexity of OI projects (Winkelbach & Walter, 2015) or of other aspects or risks of project management (Wang et al., 2010). Persisting tensions can be linked to studies focused on paradox theory and lie at the core of defining paradox (see e.g. Schad et al., 2016; Smith & Lewis, 2011). While it is well-known that tensions between value creation and value capture are also labeled as a paradox (Arora et al., 2016; Foegen et al., 2019; Lauritzen & Karafyllia, 2019; Laursen & Salter, 2014), the notion of persisting tensions has received little attention in relation to tensions of value creation and capture. As our findings strongly refer to risks and potential occurrence of misappropriation, and since we only can observe potential beginnings of sequential tension loops, we suggest that these could be analyzed further with longitudinal data.

6. Conclusions

This study set out to examine trajectories from tensions to their possible solutions in OI projects, thereby contributing to understanding the antecedents of tensions between value creation and value appropriation, and the ways of resolving such tensions. In the empirical part of our study, we pinpoint two types of trajectories: resolutions paths, which entail trajectories from initial tensions to solutions, and tension loops, where tensions persist or new tensions emerge after initial solutions have been enforced. We further identified broader categories of tensions related to asymmetry, IP and legal shortcomings (or excesses) and partner-specific tensions, and corresponding solutions of levelling, appropriability and partner selection, respectively. These broader categories of tensions and solutions further encompass a rather wide range of subcategories. We also pinpoint two narrow categories of tensions (temporal and knowledge boundaries tensions) and solutions (industry-specific conditions as solution). The narrow categories contain no subcategories of tensions or solutions. We proceed by mapping the different configurations of specific categories and subcategories of tensions and solutions characteristic to each of the 17 trajectories analyzed in our study. This map of trajectories from tensions to solutions, including resolutions paths and tension loops, is shown in Fig. 2.

While most resolution paths in our data entail singular subcategories of tensions and solutions, we find that all unresolved tension loops encompass compound tensions (bundles of two or more categories or sub-

categories of tensions) and sometimes also compound solutions. This points to more severe challenges related to value generation and appropriation in OI projects as complexity in said projects increases (Laursen & Salter, 2014). In the two resolved tension loops in our data, we identify across various loop phases combinations of tensions and solutions from different categories. This finding might suggest that if initial tensions are not effectively managed by primary solutions, resolving the persisting or newly emerged tensions may require more creative or out-of-the-box fixes.

Our investigation indicates that different types of tensions are more or less responsive to the managerial interventions and corrective actions. Specifically, our analysis points to asymmetry-related tensions being more likely resolved if all partners involved in an OI project have the willingness to level the said asymmetries. At the same time, we find solutions related to appropriability measures (e.g. contractual upgrades such as milestones or framework agreements) to be broadly ineffective for a wide range of tensions. We interpret this as a managerial effort to enhance value capture without having the appropriate tools to resolve the underlying tensions. It might be possible that certain inherent tensions are immune to readily available solutions, or that the solution actually induces new tension, thus giving start to persisting tension loops. Only two out of ten tension loops identified in our data have working solutions, while the other eight remain unresolved. Our study unravels new indicators of complexity for tensions related to value creation and capture: first, by pinpointing persisting or new tensions, after solutions are enforced, and second, by outlining bundled tensions and solutions. Our findings also delineate specific configurations of effective and ineffective combinations of tensions and solutions.

6.1. Theoretical contributions

In broad terms, our study contributes to the OI literature by expanding our understanding of value creation and value capture tensions and their solutions (see Lorenz & Veer, 2019) and to project management literature, by highlighting the uncertainties and risks brought along by complex tensions, which may be present in OI projects.

The trajectories pinpointed in our study could be interpreted using a dynamic contingency perspective (Bledow et al., 2009), which shows how second-generation innovations are utilized to answer problems that first generation solutions have produced. The initial phases of the trajectories, where tensions occur, could be regarded as a thesis, and the subsequent phase as anti-thesis.

This logic further relates to that of paradox theory, where paradoxical tensions are defined as persisting over time (see e.g. Schad et al., 2016; Smith & Lewis, 2011). By pinpointing the tension loops where tensions persist or new tensions occur after primary solutions were enforced, our study also contributes to further framing tensions between value creation and value capture in OI as paradoxical, i.e. persisting over time (Lauritzen & Karafyllia, 2019; Niesten & Stefan, 2019).

Additionally, our study contributes to theory by highlighting the complexity of tensions related to the creation and capture of value (Laursen & Salter, 2014), via compound tensions in initial, as well as in subsequent phases of tension loops. As previously mentioned in our literature review, prior studies tend to adopt a one-on-one logic by suggesting single solutions to individual tensions. Nevertheless, our analysis shows that such solutions might be ineffective and that individual tensions out of a tension bundle may persist, thus requiring subsequent or more complex solutions.

By pinpointing empirically solutions that are effective for certain tensions, while ineffective for other tensions, our study advances the discussion on the potential dual role of factors related to value creation-value capture tensions (Niesten & Stefan, 2019). It is of utmost importance to identify which tensions are resolved by such solutions, and which tensions are not alleviated, in order to successfully balance value creation and appropriation in OI.

6.2. Managerial implications

Our findings highlight the complexity of managing these tensions in OI projects, and the importance of appropriate project management tools. As noted by Brunswicker and Vanhaverbeke (2015), integrative organizational practices are needed throughout different organizational levels. Resource allocation and construction of the project teams are of primary importance.

Especially the possibility of multiple, sequential tension loops and complex tensions makes it highly relevant to be prepared for multiple rounds of solutions and not to rush to employ ‘obvious’ solutions. Concerning the latter, our study shows that the majority of unresolved tension loops are addressed by solutions related to appropriability measures. While such solutions might be intuitively appropriate to address difficulties to capture value and thus restore value creation-capture balance, a deeper analysis reveals that tensions in OI projects might require more bespoke solutions. An example would be that asymmetry-related tensions often appear to require solutions linked to levelling the asymmetries. Nevertheless, managers should be cautioned that levelling asymmetries in OI projects stems from good intentions and willingness to make adjustments from all partners involved. At the opposite pole, severe opportunism is difficult to tackle and so far our analysis points to no complete and effective solutions for it.

Managers should also be aware that the extreme degrees of openness (or closedness) have proved to be ineffective or harmful to OI projects. Specifically, the need to remain open to ‘win work’ is likely to entail higher risks of knowledge leakage. Partly closing the OI process due to prior experiences of leakage or misappropriation is not desired either, as it might acutely diminish the opportunities to create value. A very careful calibration of the degree of openness in OI projects is thus required.

Time may be a crucial element in OI projects and could also contribute to emergence of tensions, for example by putting strain on building trust. Our study provides some insights into circumventing tensions in time-sensitive projects. For instance, if a fast-paced OI project does not allow the time to build trust and align interests with partners, relying on third parties’ resources and using them for checking the partners’ reputation might be the next best thing. Combined, our findings can increase the awareness of OI project managers about tensions, their nature, and their solutions, and may help them find suitable approaches in various projects.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1. Interview protocol

Key questions (case companies)

1. Has your company collaborated with external partners in innovation (e.g. developing new products, services or processes)?
2. What are the main drivers (motivation) for engaging in collaboration with external partners?
3. Have you experienced challenges related to the above described paradox in practice? (if so, please describe further)
4. What types of partners did you experience challenges with in collaboration?
5. What was the collaboration context?
6. What were the factors that amplified tensions in innovation collaboration (possibly leading to IP misappropriation)?

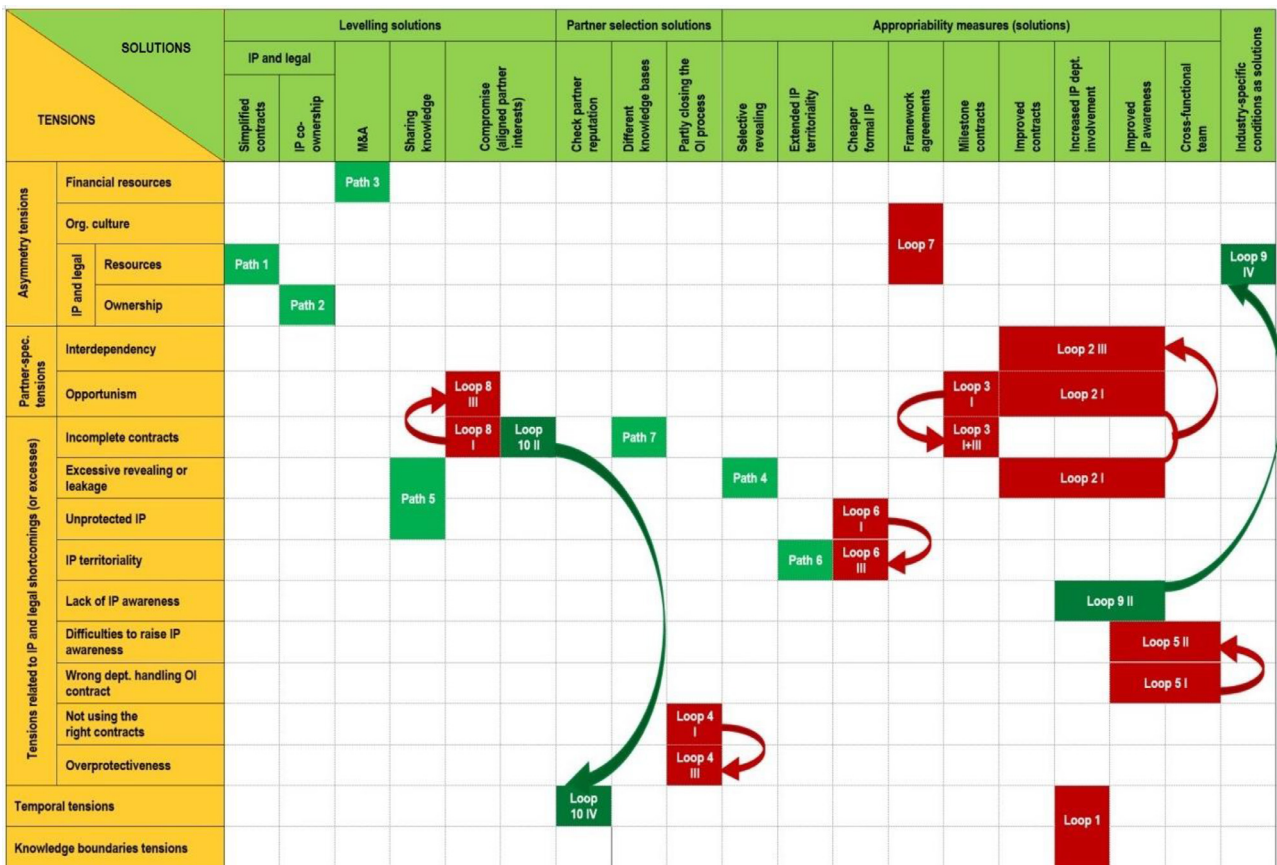


Fig. 2. Map of trajectories to create and capture value in OI projects.

7. Which IP protection mechanisms were enforced in the collaboration? (e.g. patents, trade secrets, NDAs, etc.)
8. Were the tensions resolved?
9. Did your company capture/appropriate the expected benefits from this endeavor?
10. Depending on the answer to question 9, please describe the factors or mechanisms that had a role either in alleviating tensions in the collaboration, or in leading to insufficient value capture and/or misappropriation of IP

Key questions (expert informants)

1. What is your experience of challenges in practice relating to creating and capturing value in interorganizational innovation collaboration? (if so, please describe further)
2. In your experience, are there any specific factors that might amplify tensions in innovation collaboration, thus leading to cases of IP misappropriation?
3. Which factors from the answer to question 2 would you pinpoint to be of high importance?
4. Have you experienced innovation partnerships that prevailed despite challenges to appropriate IP?
5. Please describe the factors or mechanisms mentioned in the answer to question 4, which had a role to alleviating said challenges.

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