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Technological competence leveraging projects via intermediaries: Viable means to outbound open innovation and mediated capability building?

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A B S T R A C T

Aiming at reaping the benefits of open innovation, a growing number of organizations utilizes innovation intermediaries as external facilitators. However, the effectiveness of such intermediaries, especially in outbound open innovation, such as leveraging existing technologies in new market opportunities, remains unclear. We aim to investigate if and how externally conducted technological competence leveraging (TCL) projects provide value to the focal organization. Based on interviews with key personnel and analysis of reports from such projects conducted in the course of several research consortia at CERN, the European Organization for Nuclear Research, we find that the projects were successful in identifying new application fields. Further, the externally conducted projects also contributed to the development of TCL-related project capabilities within the focal organization. This research also identifies a number of barriers to short- and long-term success such as lack of a company-internal perspective and project owners without management responsibilities.

Introduction

Open innovation is a relatively new and nowadays widely recognized approach to innovation management. It denotes the idea to use *"…purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively"* (West, Vanhaverbeke & Chesbrough, 2006). The potential merits of open innovation have been studied quite extensively: One the one hand, open innovation activities may contribute to generating new or increasing existing revenue streams. This can be achieved in different ways, e.g., by externally commercializing internal knowledge (Arora, Fosfuri & Gambardella, 2001; Deck, 2008) and/or sourcing external knowledge to utilize it in the development of products that are radically new (Franke, Von Hippel & Schreier, 2006; Lilien, *Morrison,* Searls, Sonnack & Von Hippel, 2002) or particularly well in line with the users' preferences (Franke, Keinz & Steger, 2009). On the other hand, open innovation might help to cut down time and money spent during R&D processes, e.g., by leveraging the creative potential and workforce of external actors (Brabham, 2008; Newton et al., 2010) and/or reducing the number of trial-and-error loops with users necessary to test new product ideas (von Hippel, 2005; Von Hippel & Katz, 2002).

While the promise of open innovation is undisputed, many organizations seem to face difficulties in leveraging its potential. Empirical studies found no or even a negative relationship between openness and (firm) performance (Lhuillery & Pfister, 2009; Un, Cuervo-Cazurra & Asakawa, 2010). Also, in a recent study among 125 large firms from Europe and the United States, the participants reported only modest satisfaction[1] with the results of their open innovation initiatives (Chesbrough & Brunswicker, 2014). The major reason as to why organizations fail to fully benefit from open innovation can be found within themselves: They lack the necessary competences to effectively pursue open innovation strategies (Brunswicker & Chesbrough, 2018; Keinz, Hienerth & Lettl, 2012). Teece and other advocates of the resource-based view of the firm refer to those abilities and competences in the implementation and management of strategic innovation processes as dynamic capabilities (Davies & Brady, 2016; Davies, Dodgson & Gann, 2016; Teece, 2012; Teece, Pisano & Shuen, 1997). They are of particular importance, as they determine the speed at, and the degree to which an organization is able to realign itself to match external requirements and/or opportunities to generate sustained, positive returns (Teece, 2012).

Because of the potentially high benefits of open innovation strategies on the one hand, and the lack of necessary dynamic capabilities on the other hand, a growing number of organizations decides to "outsource" their open innovation activities. To do so, they draw on so-called innovation intermediaries (Hossain, 2012; Howells, 2006; Katzy, Turgut, Holzmann & Sailer, 2013). Such innovation intermediaries can be defined as "*an organization or a body that acts as an agent or broker in any aspect of the innovation process between two or more parties*" ((Howells, 2006): 720). The underlying idea of collaborating with an innovation intermediary is simple: The focal organization defines a specific open innova-

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[1] The respondents' average satisfaction level was 4.7 on a 7-point scale, ranging from 1= not at all satisfied to 7=highly satisfied.

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tion project and delegates its planning and management to an external partner with the necessary skills and competences. This approach potentially offers two advantages. First, because of the innovation intermediary's specific project capabilities (see Brady & Davies (2004), the project is much more likely to yield valuable and applicable results (Du, Leten & Vanhaverbeke, 2014). Second, the outsourced project can be considered a learning opportunity. By observing and analyzing the way the innovation intermediary manages the open innovation project, the focal organization might accumulate know-how and thus start to develop the relevant open innovation-related project capabilities at the operational level (Brady & Davies, 2004) itself, which are the basis for building more strategic dynamic capabilities (Davies & Brady, 2016).

However, is outsourcing open innovation projects a viable approach? Does it yield satisfying project results in the short run? And even more importantly, does it actually help organizations to develop the specific open innovation-related project capabilities in the long run, which in turn are an important pre-condition for organizations to pursue open innovation strategies successfully? To date, the scientific literature does not provide clear and exhaustive answers to these questions. So far, only few research projects have looked into the effectiveness of open innovation intermediaries (Basche, 2007; Hargadon & Sutton, 1997; Jeppesen & Lakhani, 2010; Sawhney, Prandelli & Verona, 2003; Sieg, Wallin & von Krogh, 2010; Verona, Prandelli & Sawhney, 2006). In all these cases, the open innovation intermediaries are predominantly seen as agents for inbound open innovation projects. This means that they are considered a means for the focal organization to source external knowledge useful in resolving some type of internal challenge, e.g., developing a new product idea (Chesbrough, 2003). In contrast, externally conducted outbound open innovation activities, and specifically technological competence leveraging, i.e., the process of systematically searching for, evaluating, and exploiting new market opportunities to internally developed technologies (Danneels, 2007; Keinz & Prügl, 2010), has not received a lot of academic attention. To the best of the authors' knowledge, only two papers report on the outcomes of technological competence leveraging projects that had been managed by university institutes on behalf of technology-driven companies (Henkel & Jung, 2009; Keinz & Prügl, 2010). This lack of scientific insights is particularly surprising because externally commercializing internally developed knowledge via technological competence leveraging is generally considered an extremely important strategic activity (Barca & Barca, 2018; Danneels, 2007; Deck, 2008; Gruber, MacMillan & Thompson, 2008; Keinz & Prügl, 2010). Irrespective of the type of open innovation activity, it remains questionable if an outsourced open innovation project actually contributes to building related project capabilities within the focal organization. Existing literature on organizational learning supports the idea of project-based capability learning (Brady & Davies, 2004; Davies & Brady, 2016). It emphasizes, however, the necessity for the focal organization to conduct the respective projects themselves in order to gain experiences first hand (Defillippi & Arthur, 2002; Prencipe & Tell, 2001). When outsourcing an innovation project to an external intermediary, first hand experiences will occur only to a much lesser extent, limiting the focal organizations' likelihood to build innovation-related dynamic capabilities.

Given these gaps in the current literature, in this research we aim to investigate if and how externally conducted outbound open innovation projects, and more specifically technological competence leveraging projects, provide value to the focal organization. We want to shed light on both, the potential short-term merits (e.g., the actual identification, evaluation, and exploitation of application fields) as well as the potential long-term merits with regards to the development of project capabilities. In addition, we aim at identifying the most important challenges in the course of such projects and deriving suggestions on how to organize such projects to increase the likelihood of a valuable project outcome.

By addressing these research questions, we heed the call of this special issue to generate insights *"…on how to best strategize and organize open and user innovation activities, and how to develop people and their values to support cooperation with external individuals and/or organizations."* (Keinz, Hienerth, Gemünden, Killen & Sicotte, 2018). The insights generated in this research project are intended to inform both scientists as well as practitioners about means of increasing the efficacy of open innovation activities. The ultimate goal is to help organizations to better leverage their technological resources. By focusing on technological competence leveraging projects conducted by innovation intermediaries on behalf of the focal organization, we also contribute to the open innovation literature in two additional ways: First, we add to the relatively scarce literature on outbound open innovation approaches. Researchers from the open innovation domain have been stressing the importance of additional insights into the process of leveraging internal (technological) knowledge (Dames, 2017; West & Bogers, 2017). Second, we generate insights into the ongoing debate about the effectiveness of open innovation intermediaries (Diener, Luettgens & Piller, 2020; Radnejad, Vredenburg & Woiceshyn, 2017; Randhawa, Josserand, Schweitzer & Logue, 2017).

By analyzing the process of mediated project-led development of open innovation-related project capabilities by the focal organization, we are also complementing the literature on organizational learning. Project-based capability development itself is a well-established concept (Brady & Davies, 2004; Davies & Brady, 2016; Defillippi & Arthur, 2002). The academic literature, however, so far has only started to look into the viability of externally conducted projects as a source of organizational learning. Our research sheds light on the question whether or not, and if yes, which specific open innovation-related project capabilities can be developed via project-based collaborations with open innovation intermediaries.

Literature review and framework

A capability view on technological competence leveraging

Technological competence leveraging (TCL) is a specific outbound open innovation strategy (Faems, 2008). It refers to the process of systematically searching for, evaluating, and exploiting new market opportunities for new or existing technologies of the focal organization (Danneels, 2007; Keinz & Prügl, 2010). From a theoretical perspective, TCL is deeply rooted in the resource-based view of the firm. The central idea of this theoretical stream is that organizations gain competitive advantage because of hard to imitate, superior resources that set them apart from their competition (Barca & Barca, 2018; Barney, 1991; Prahalad & Hamel, 1990; Wernerfelt, 1984). Technologies and/or technology-related competences have been identified to be among the most important resources to positively affect innovation and wealth creation with a firm (Gruber et al., 2008; Shane, 2004). That is because technologies are particularly fungible resources: One technology can underlie many different products and thus cater various market applications (Danneels, 2002; Hargadon & Sutton, 1997; Patel & Pavitt, 1997; Teece, 1982).

Despite their potential fungibility, many technologies/technological competences remain "underutilized". Already the seminal work by Penrose emphasized that resources are often not fully exploited (Barca & Barca, 2018) and Burgelman added to this notion by stating that "*…the productive potential of a firm's technological competences may extend beyond the boundaries set by its product-market strategy at any given time.*" ((Burgelman, 1994): 48). Obviously, the underutilization of technologies and/or technological competences comes with opportunity costs, since not all potential value is extracted from the respective resources (Thomke & Kuemmerle, 2002).

To reduce the problem of underutilization of technological resources, organizations have to pro-actively look for, evaluate, and exploit new market opportunities for their technologies, i.e., they have to conduct TCL activities (Danneels, 2007). The potential benefits of pursuing TCL activities are manifold: firstly and most importantly, catering new markets with an existing idea increases the return on investment in past R&D expenditures. In addition, it decreases an organization's strategic dependency from its current target market(s) (Danneels, 2007; Danneels & Frattini, 2018; Keinz & Prügl, 2010). For start-ups and new ventures, TCL activities help build and assess a portfolio of market opportunities before actually entering a specific market, which increases the likelihood to thrive (Gruber et al., 2008). Being able to potentially cater more than just one market might also be an important argument towards investors, who generally look for businesses with growth perspectives (Bansal & Yaron, 2004; Cronqvist, Siegel & Yu, 2015; Fama & French, 1996; Gârleanu, Kogan & Panageas, 2012). Because of all these potential, positive effects of TCL activities on the one side, and a business environment that changes at increasing speeds on the other side, more and more technology-driven organizations aim at developing TCL-related competences.

From a capability perspective, successful TCL activities on an ongoing basis require both, dynamic capabilities at the strategic level as well as project capabilities at the operational level. Literature describes dynamic capabilities as meta-level competences that determine the speed at, and the degree to which an organization can (re-)align its internal resources – including project capabilities – and match them with new external conditions, requirements, and upcoming new market opportunities (Davies & Brady, 2016; Teece, 1982, 2012; Teece et al., 1997). Teece distinguishes three different types of dynamic capabilities: 1.) sensing, which refers to the ability to identify and assess an opportunity; 2.) seizing, which refers to an organization's ability to mobilize resources to address the opportunity and actually capture value from it; and 3.) transforming, which represents the ability to continuous renewal of an organization (Teece, 1982, 2012; Teece et al., 1997). Interestingly, the sensing and sizing capabilities match perfectly with the core elements of TCL activities, which are the identification, evaluation, and exploitation of new market opportunities to a focal organization's technology (see next chapter). However, an organization's strategic-level dynamic capabilities are closely linked to its operational-level project capabilities. TCL activities will only be successful if the organization possesses the necessary competences to actually identify and evaluate new market opportunities as well as to come up with commercialization strategies. This is where project capabilities come in. The concept of project capabilities refers to the knowledge, experiences, activities and structures required by an organization to manage a project through its life cycle (Davies and Brady, 2000). Project capabilities build over time through repetition of a specific type of project and accumulating valuable first-hand knowledge and experiences. These economies of repetition "*…provide strategic focus, emerging insights and valuable signposts for the future direction of the firm…*" and thus provide the ground for a bottom-up development of dynamic capabilities.

The current paper builds on these insights. We argue that a series of TCL projects – even if conducted externally by an intermediary – leads to the development of TCL-related project capabilities at the operational level (i.e., all competences needed to manage a TCL project through its life). These project capabilities should enable the focal organization to conduct TCL projects internally in the long run and also facilitate the development of strategic-level dynamic capabilities, such as sensing, sizing, and transforming (Teece, 1982, 2012; Teece et al., 1997). To be able to explore the building of TCL-related project capabilities, we continue by revisiting the literature on the organization of TCL activities.

The organization of technological competence leveraging activities

Literature describes various different approaches to TCL. Examples are Souder's *total systems approach to technology push* (Souder, 1989), Danneel's de-linking/re-linking approach (Danneels, 2007; Danneels & Frattini, 2018), the technology-push lead user concept (Henkel & Jung, 2009), the user community-based approach to technological competence leveraging (Keinz & Prügl, 2010), as well as the market opportunity navigator (Gruber & Tal, 2017). While these approaches differ in many aspects, they share an underlying fundamental logic. All of them are systematic processes that feature four generic steps: in the first step, the technology that is to be leveraged is analyzed from a potential users' perspective. The primary goal of this step is to understand what type of problem the technology solves in the current target market, i.e., revealing the technology's core benefits from a user's perspective. The subsequent second step is a systematic search for analogous application fields for the technology, e.g., via creativity techniques, social search techniques like pyramiding (Stockstrom, Goduscheit, Lüthje & Jørgensen, 2016; von Hippel, Franke & Prügl, 2009) and/or broadcast search (Jeppesen & Lakhani, 2010), patent database searches (Danneels & Frattini, 2018) etc. Such analogous application fields are industries in which similar problems as in the target market exist, thus, actors in these industries are likely to benefit from the solution delivered by the focal technology. After having identified a reasonable number of potential applications, they have to be evaluated and ranked with regard to their commercial viability (step three). This activity is crucial for the organization to be able to make a decision on which application field(s) to focus further on in the TCL process. Last but not least, step four comprises the development of an actionable strategy to enter and cater the newly identified application fields. Fig. 1 features an illustration of a typical TCL process.

Another similarity of most TCL approaches is that they describe TCL activities as non-routine tasks that are conducted in the form of projects (Danneels, 2007; Henkel & Jung, 2009; Keinz & Prügl, 2010). This observation is in line with other research indicating that the vast majority of innovation activities is organized within project frameworks (Cassiman, Di Guardo & Valentini, 2009; Hobday, 2000; Midler, Killen & Kock, 2016; Sydow, Lindkvist & Defillippi, 2004). A special feature of TCL projects, however, is the fact that they are usually designed as open innovation projects. In 1989, and thus long before open innovation became a phenomenon widely discussed among scientists and practitioners, William Souder already pointed to the importance of involving external actors into TCL projects. He described the necessity to broadcast *"…a knowledge of the technology…as widely as possible throughout both the research and user communities…[…]…to maximize the chances of a collision between the technology and its potential uses"* (Souder, 1989). Other authors have also highlighted the role of external actors in the course of TCL projects. For example, Henkel and Jung (Henkel & Jung, 2009) show how lead users may contribute to TCL processes, and Keinz and Prügl (2010) recommend to involve innovative user communities. The underlying idea is always the same: By integrating external actors, preferably current and potential users with various backgrounds, it is much easier to overcome the two biggest barriers to successful TCL projects. Those barriers are the focal organization's predominantly technological perspective as well as its local search bias (Keinz & Prügl, 2010).

The technological perspective aspect refers to the fact that the focal organization, i.e., the inventor of the technology, tends to start into TCL activities with a solution-based search specification. This means that the technology is usually described based on its technological specifications, features, and functionalities rather than the benefits it delivers to its users. In the most extreme case, the focal organization presents its technology by providing the official patent. This makes it much harder – if not almost impossible – for potential users from other domains that are not familiar with the technical jargon to recognize the technology as a solution to a problem that they have in their domains (Arora & Gambardella, 1994; von Hippel, 1994). By integrating actual users of the technology into the first step of the TCL project, i.e., the analysis of the technology's problem-solving capability, the problem of solution-based search specifications can be easily overcome. Users with use experience know much better than the inventors how they derive benefits from using the technology as well as which problem it solves and its major flaws (DeMonaco, Ali & Von Hippel, 2006; von Hippel, 2005; Von Hippel & Katz, 2002). They will usually also be prepared to convey

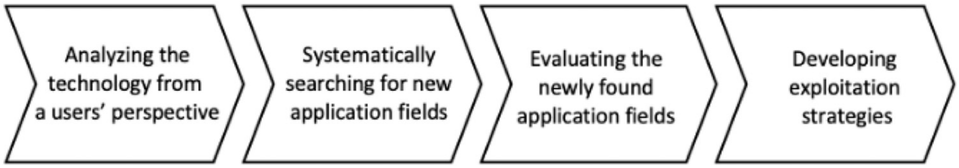

Fig. 1. The core phases of *technological competence leveraging* processes
Source: Source: Based on Daneels (Danneels, 2007) and Keinz & Prügl (Keinz & Prügl, 2010).

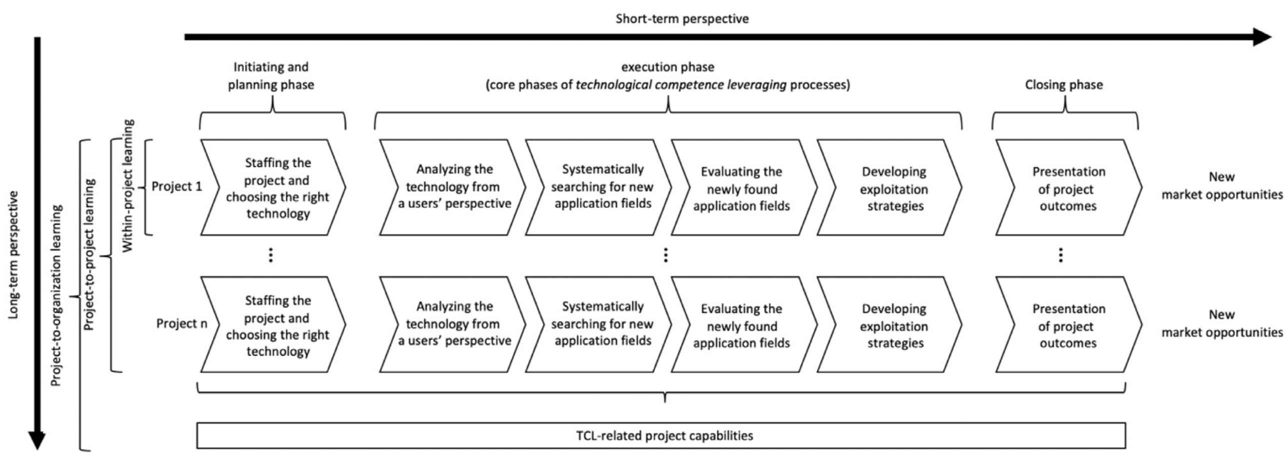

Fig. 2. Framework for organizing successful, externally conducted *technological competence leveraging* projects.

this information in simple, widely understandable terms. Based on such a non-technical problem-based search specification, it becomes much easier for potential users from other domains to understand what the technology can do for them (Keinz & Prügl, 2010). This increases the likelihood of finding valid additional applications to the technology (Souder, 1989).

The second important barrier to successful TCL projects are what literature refers to as local search bias (Rosenkopf & Nerkar, 2001; Stuart & Podolny, 1996). When looking for additional applications to its technology, the focal organization is draws on its past experience, its existing knowledge base, ideas, and network. This approach is likely to yield non-novel solutions only, since it limits an organization's ability to get out of the box and discover applications that are unrelated to the organization's knowledge base (Shane, 2004). Involving potential users from various domains into the search for additional applications to a technology is a highly effective way to overcome the local search bias (Poetz & Prügl, 2010; von Hippel, 1994). While individual users also fall victim to local search bias, user communities, as a social entity, will not – or only to a much lesser degree. Since they consist of individuals with various and different experiences and knowledge bases and thus comprise various and different local search behaviors, their search for possible applications will be much broader (Keinz & Prügl, 2010).

The need to open up TCL projects and to involve users leads to an interesting phenomenon: Many organizations decide to not manage their TCL projects themselves but rather outsource this task to open innovation intermediaries (Hossain, 2012; Howells, 2006; Katzy et al., 2013). The major reasons for this are twofold: First, most organizations face difficulties in opening up their innovation activities as this requires a difficult change process (Brunswicker & Chesbrough, 2018; Chesbrough & Brunswicker, 2014). Second, they often lack – at least initially – the necessary capabilities and methodological competences to effectively manage relationships to a large number of externals that participate in their innovation processes (Brunswicker & Chesbrough, 2018; Chesbrough & Brunswicker, 2014). Open innovation intermediaries, in contrast, do have specific expertise and experience in conducting TCL projects. They are typically either specialized companies running online market places like InnoCentive, NineSigma and Yet2.com (Hossain, 2012; Sieg et al., 2010) as well as consultancies (Danneels & Frattini, 2018; Hargadon & Sutton, 1997; Souder, 1989), or universities that offer to conduct open innovation projects for partners in the course of their research and/or teaching activities (Henkel & Jung, 2009; Keinz & Prügl, 2010). Because of their specific skills and methodological know-how, they are capable of professionally managing open innovation projects and thus increase their likelihood for success (Du et al., 2014; Sieg et al., 2010).

Towards an integrated framework for assessing the success of externally conducted TCL projects

Remember: In this paper, we set out to investigate if and how externally conducted TCL projects provide value to the focal organization. Answering this question, we distinguish between potential short-term merits (e.g., the identification, evaluation, and exploitation of application fields) as well as potential long-term merits with regards to the development of project capabilities. In addition, we aim at identifying the most important challenges in the course of such projects and deriving suggestions on how to organize such projects to increase the likelihood of a valuable project outcome.

To answer these questions, we derived an integrated framework for assessing the success of externally conducted TCL projects (see Fig. 2). Our framework builds on literature from the open innovation domain as well as the field of organizational learning, and more specifically project-led learning.

Analyzing the short-term merits of externally conducted TCL projects

Anecdotal evidence indicates that open innovation intermediaries, possessing relevant project capabilities, are actually able to identify new and commercially promising application fields to a given technology of the focal firm (Danneels & Frattini, 2018; Henkel & Jung, 2009; Keinz & Prügl, 2010). It remains unclear, however, if these application fields are actually exploited later on and thus whether or not the TCL activities yielded a measureable economic outcome. In addition, we do not know much about how to organize TCL projects to increase the likelihood of a valuable project outcome. Consequently, we want to shed light on the most important success factors and challenges in the management of

TCL projects conducted by open innovation intermediaries. So far, literature has indicated three recurring, major challenges for organizations outsourcing innovation projects to intermediaries (Sieg et al., 2010): 1.) enlisting (the right) internal staff to work with the open innovation intermediary; 2.) selecting the right problems (technologies) to be worked on; 3.) formulating the task to be worked on in a way that enables the intermediary to come up with valuable solutions.

To elaborate on these and additional challenges, it is important to analyze TCL projects from a project management perspective. Thus, at the heart of our framework are the four core steps of technological competence leveraging processes (as described by the literature and depicted in Fig. 1). From a project management perspective, those steps only make up the execution phase of a TCL project and need to be complemented by an initiating and planning phase as well as a closing phase (Ahlemann, 2009; Morris, 2008). In the case of externally conducted TCL projects, the execution phase is usually managed autonomously by the open innovation intermediary. In contrast, the initiating and planning phase as well as the closing phase of TCL projects depend on inputs of both stakeholders involved, the open innovation intermediary as well as the focal organization (Souder, 1989). Finding the "right" technology that is to be leveraged and assigning members of the focal organization to act as sparring partners to the intermediary and recipients of the project outcome presentation are vital functions fulfilled by the focal organization (Howells, 2006; Sieg et al., 2010).

Analyzing the long-term merits of externally conducted TCL projects

As indicated above, our framework does not only focus on short- but also on long-term merits of externally conducted TCL projects. Since TCL activities are not meant to be "one shot" initiatives but rather an enduring effort, the question arises whether externally conducted TCL projects actually enable the focal organization to build up TCL-related project capabilities themselves. This would be an important pre-condition for the organization to be able to successfully explore new markets on a continuous basis.

In order to answer the question raised above, our framework draws on literature on project-led organizational learning. Many authors have advocated the notion that projects are important means for organizations to learn and acquire new competences (e.g., Middleton, 1967; Davies and Brady, 2000; (Prencipe & Tell, 2001)). However, previous research also points to the difficulties for firms to capture the learnings gained through projects and transfer them to their wider organizations for their long-term benefits (e.g., DeFillippi, 2001; Keegan and Turner, 2001). In their seminal work on building *project capabilities*, Brady and Davis tackle these critiques to project-based learning. They suggest to interpret and analyze project-based learning as a dynamic process of building specific knowledge and experiences required to set up and implement a certain type of project (Davies and Brady, 2000; Brady & Davies, 2004)). Their project capability-building model features three different, subsequent phases, ranging from within-project learning (within an initial "vanguard project") to project-to-project learning and project-to-organization learning. According to this model, organizations can increase their learning effects by transitioning from unique to repetitive projects. Repetition allows for the development of the routines required to achieve economies of repetition in the new project category and to build specific *project capabilities* at the operational level over time (Brady & Davies, 2004).

Our framework builds on Brady and Davies' project capability-building model. It features the three project-led learning mechanisms related to vanguard and follow-up projects and applies them to the context of building TCL-related project capabilities. It is noteworthy though to mention a very important deviation of our framework from the project capability-building model as described by Brady and Davies and similar approaches to project-based learning: Our framework focuses on the case of mediated capability building, i.e., capability building via externally-conducted projects. To date, most of the research on capability building including the work of Brady and Davies, emphasizes the necessity for the focal organization to move into a new category of projects themselves and gain experiences first hand, that might later translate into the development of a set of capabilities (Defillippi & Arthur, 2002; Prencipe & Tell, 2001). It thus seems worth investigating whether or not externally-conducted *TCL* projects actually support the process of project-based capability building.

Method

Research approach

Our research questions are exploratory in nature. Only limited literature is available to shed light onto the phenomenon of externally conducted TCL projects. Consequently, we conducted an in-depth case study. This research approach allowed us to investigate causes and relationships in great detail and over a longer period of time (Chakraborty et al., 2014; Lichtenstein et al., 2006). It also enabled us to integrate the viewpoints of various actors, helping to avoid potential single informant biases and considering alternative explanations to our observations. Because of its specific advantages, case study designs have been used frequently in fields related to new technological opportunities (O'Connor, 1998; Song & Montoya-Weiss, 1998).

To answer our research question, a case study would have to fulfill three key requirements: First, the focal organization would have to possess technologies that it wants to find new applications for while at the same time not possessing the required skills and resources, thus conducting their outbound open innovation activities with an intermediary. Second, in order to assess the potential for long-term learning, the organization must have an interest in acquiring the relevant capabilities. Finally, given the short- and long-term perspective, a suitable case would consist of multiple projects over an extended timeframe. Taking these requirements into consideration, the context of this case study is three Innovative Training Networks (ITNs) under the Marie Skłodowska-Curie Actions that have been put together and organized by CERN, the European Organization for Nuclear Research. ITNs are multi-year programs funded by the European Union and aim at bringing together a consortium of early stage researchers, companies, research institutes (such as CERN) and universities throughout Europe. The three ITNs being analyzed were conducted in sequential order. The first ITN was TALENT (Training for cAreer deveLopment in high-radiation ENvironment Technologies), focused on the development of instrumentation for radiation detection such as radiation-hard precision pixel sensors as well as high-density electronics and interconnection technologies. STREAM (Smart Sensor Technologies and Training for Radiation Enhanced Applications and Measurements) focused on the scientific design, construction and manufacturing of advanced radiation instrumentation such as radiation-hardened CMOS sensor technologies. EASITrain (European Advanced Superconductivity and Training) was still ongoing by the time the authors wrote this article. It focused on various technologies related to applied superconductivity such as superconducting wires, superconducting thin films, related manufacturing and processing techniques and innovative cryogenic refrigeration. Since all three consortia were hosted by the same organization and followed the same logic and structure, we treat them as similar initiatives within one case organization (CERN).

A core component in all three of these consortia were series of externally conducted TCL projects, with the Vienna University of Economics and Business serving as the open innovation intermediary. The university's main interest in participating in these projects was to apply the existing expertise in the TCL methodology and to generate new insights into an effective application of TCL projects in scientific and industrial settings. A further benefit for the university was the hands-on experience with the methodology gained by researchers and students. To allow for the collection of unbiased insights, the university conducted the open innovation projects in a similar form as other external intermediaries would, putting the partners' success and outcome of the projects at the center-stage of all activities.

Table 1
Overview of the Innovation Training Networks (ITNs) and Conducted TCL Projects.

ITN	Technology	Project owner	Project details			Remarks
			Identified application fields	Detailed application fields	No. of experts interviewed	
TALENT	CVD diamond detector	Company	19	2	40	Interviewee 1
	Direct laser soldering	CERN	8	3	50	Interviewee 2
	HV CMOS	CERN	18	8	85	Interviewee 2
	Microscint technology	CERN	16	4	65	
	Depleted CMOS sensor	CERN	20	3	40	Interviewee 2
STREAM	Rad-hard CMOS sensor	Company	37	3	45	Interviewee 3
	Electron microscopes	Company	30	3	200	
	Near- and medium infrared	Company	47	3	140	
EASYTRAIN	Superconductors	CERN	29	3	120	Interviewee 4
	Superconductor manufacturing	CERN	21	6	40	Interviewee 4

In total, the Vienna University of Economics and Business served as the open innovation intermediary for ten projects (see Table 1). The owners of these projects were both companies as well as research organizations from the consortium whose main motivation was to identify new application areas for existing technologies. In the science and technology-driven setting of scientific consortia, disseminating technology outside the pure scientific use is both a part of the mission of organizations such as CERN, as well as an economic necessity for the industrial consortium members, due to the non-continuous demand of science organizations.

A typical TCL project within the ITNs had a duration of 4 months (the duration of one academic term) and, on the side of the intermediary, involved a team of 5 to 8 people. While the people assigned to an individual TCL project had diverse backgrounds, only a small minority of them had prior training or practical experience in science or engineering. On the project owner's side, there were 1 to 3 people involved, usually management staff with a physics or engineering background. The projects started with a kickoff meeting, during which the project owner introduced the technology to the intermediary's project team. The project team then analyzed the project owner's technology from a users' perspective and subsequently conducted a wide search for possible applications using methods such as pyramiding and broadcast search (Jeppesen & Lakhani, 2010; von Hippel et al., 2009) as well as research on available data sources such as online sources and patents. Based on the outcomes of the research phase that had a duration of 2 months, a list of possible application fields, on average around 21 fields, was created and presented to the project owners in the course of a steering board meeting. The intended outcome of these steering board meetings was a shortlist of the three most commercially attractive and technologically feasible application fields. For each of those, a more detailed market and competitor analysis as well as a market entry strategy were developed. The results of the projects, including identified application areas, the market and competitor analyses, the market entry strategies, and list of contacts were then provided to the project owners in the form of a written, final report. One example of a technology, for which a TCL project was conducted, is the HV-CMOS sensor, originally developed for use in one of the particle detectors at CERN's Large Hadron Collider, the world's largest particle accelerator. Over the course of 4 months, the project team at the Vienna University of Economics and Business interviewed more than 85 experts in different fields and identified 18 application fields for the technology. More detailed market and competitor analyses as well as a market entry strategy was performed regarding the application of the technology in electron microscopes and in the field of particle therapy, an increasingly important tool in cancer treatment.

Data collection

To answer the questions whether and in which ways the conducted projects provided value to the project owners' organizations, what challenges they faced during the projects, and whether or not these projects actually helped to build TCL-related dynamic capabilities, we conducted a series of qualitative interviews. Interview partners were different project owners, including personnel from CERN as well as two companies who were all partners in the before mentioned consortia (see Table 1). All interviewees had been involved directly in the externally conducted TCL projects. During the projects, all of them had been responsible for overseeing and coordinating the outsourced TCL activities. In addition, all of them are still affiliated with the respective organizations, and are thus capable to provide information on short-term effects as well as long-term learning effects beyond the scope of the individual projects.

The semi-structured interviews lasted between 30 to 120 minutes. The interviews were conducted based on a questionnaire (which is provided in the Appendix) containing three types of questions: a) general information about the interviewees such as their affiliation, role in the organization, b) their experiences with the externally conducted TCL projects in terms of immediate results, issues arisen during the project, and c) learning outcomes both personal as well as within the organization. The interviews were mainly conducted by the second author, who had not participated in any TCL projects and never met the interviewees, ensuring a more objective outside perspective. All interviews were recorded and transcribed before the analysis.

In addition to data collected during the interviews, the authors could draw on additional primary data. Due to his affiliation with the Vienna University of Economics and Business, the first author of this paper was able to observe several of the TCL projects by attending close to 50 team meetings, presentations, and workshops. He was able to observe both formal and informal interactions between the open innovation intermediary's project teams that performed the TCL projects and the representatives of the project owning organizations. Further sources of data were the consortia internal protocols as well as the detailed project reports that were compiled by the project team as part of the conducted TCL projects. These reports contain detailed information on the initial goal of the projects, the scope of work, as well as initial feedback and assessments of the project outcomes by the project owners.

In sum, a good amount of both primary as well as secondary data was available to the authors. We applied triangulation, i.e., matching data from different sources in order to gain a comprehensive and more valid picture of the phenomena at the core of our research interest (Amaratunga & Baldry, 2001; Maxwell & Reybold, 2015). Such trian-

Table 2
Clusters and codes employed during the qualitative data analysis.

Cluster	Codes
Short-term project success	• Quality of output • Quantity of output • Applicability of output • Partnership outcomes
Barriers to short-term success	• Human factors • Organizational factors • Communication factors • Project management-related factors
Long-term learning outcomes	• Motivation • Dissemination of knowledge • Method-related learning • Replication of TCL projects • Application of knowledge in other settings
Barriers to achieving long-term learning outcomes	• Human factors • Organizational factors • Communication factors • Project management-related factors

gulation procedures are used to reduce different forms of biases and to decrease subjectivity in the use and interpretation of data, thus increasing the potential shortcomings of case study research (Chetty, 1996; Perry, 1998).

Data analysis

To be able to identify robust patterns emerging from the various sources, we had to reduce the quantity of the collected data. The data reduction process followed the usual procedures (Schwandt, 1996) and consisted of two steps: The first step comprised the identification of major categories, based on our literature review. Those categories fall in four different clusters, which are 1.) short-term, immediate outcomes related to the immediate outcomes of the TCL projects, 2.) long-term outcomes related to learning and capability building, as well as 3.) challenges in achieving individual project outcomes and finally 4.) challenges in building up capabilities to conduct outbound open innovation activities internally. In the subsequent second step, a total of 17 codes were identified within the major categories. The clusters and codes are listed in Table 2. The analysis was independently conducted by the two authors and cross-checked by colleagues not involved in either the TCL projects or the empirical data collection. Further discussion and analysis based on the applied codes resulted in eight patterns which are described in detail in the findings section.

Results

Short-term project outcomes

Pattern 1 – Identification of viable application fields: The intended outcome of an individual TCL project is to identify and provide an overview of commercially attractive and technologically feasible market opportunities as well as to develop strategies to enter said markets. All interviewed project owners of the externally conducted TCL projects expressed a high degree of satisfaction with these immediate outcomes. Over all projects, the open innovation intermediary's project teams were able to identify a minimum of eight and a maximum of 47 applications fields to the project owners' technologies, the majority of which were characterized by a high level of strategic fit and a high relevance with the benefits offered by the technology.

This finding should actually not be very surprising, because finding viable applications is the primary purpose of TCL projects. However, some of the project owners indicated that the large number of potential application fields identified as well as the level of novelty of those application ideas exceeded their expectations by far:

> "I was really astonished by the application ideas generated by the teams! Despite not possessing deep knowledge about our technology, they found opportunities in industries I had never thought of before."
> CERN Scientist

> "Frankly, I was very skeptical but also interested to see what they'd come up with. Some ideas were not feasible, but others were. Generally, they exceeded my expectations."
> CERN Scientist

Some of the interviewees also indicated that they would not have been able to achieve a similar outcome themselves. A main reason for not-conducting TCL activities in-house, but outsourcing them, was the lack of in-house capacities and service units for technology transfer, or in case such a unit existed, a lack method competency in TCL. Involving an external partner with methodological know-how was thus seen as a necessity:

> "We would neither have the time nor the skills to do such an extended search for applications."
> Company TCL project owner

Another advantage of having an external open innovation intermediary (without deep technological background) was the project teams' lack of functional fixedness. From the interviewees' perspective, having a team with a management background work on the TCL activities helped overcome the pre-formed ideas and conceptions that build up when being involved with the technology on a daily-basis.

> "The capacity and the unbiased approach (were great advantages). If you work with a technology daily, it really narrows your perspective."
> Company TCL project owner

Pattern 2 – Creation of technology roadmaps: For the focal organizations in our case study, the CERN-centered ITN consortia, the identification of potential application fields to their technologies was not an end in itself, but rather served several purposes. The first and probably most important one was to find market opportunities in order to show the relevance of their research to society and industry. The consortia leaders indicated that ITN grant applications to the European Union, that lacked dedicated work packages on technology valorization, were considered to have a lower likelihood to ultimately receive funding:

> "It is understandable, that if the European Union funds research endeavors like ours, they want us to think about how to give back to society. Actually, we should not only think about it, but really try hard to make technology transfer happen."
> CERN Scientist

In addition to this statement, an analysis of the grant application documents of the three ITNs indicated the importance of this aspect. All of them included work packages dealing with the topic of technology transfer. Those work packages were labeled "Knowledge and Technology" or "Technology Valorization" and described "technology roadmaps" as a major deliverable to be produced during the ITN activities. Those "technology roadmaps" were considered important not only to justify funding of the research project, but also to give direction to the consortium members during the research and development processes. A rough idea of where to apply a specific technology later on, helps the scientists to anticipate the potential technological requirements of future users. This information is highly valuable, as it allows to set specific foci during the development of the technology.

> "The value is not just discovering possible application fields for a technology. The real value is for both sides, technology and users, to become aware that technologies exist, which are unknown to many

people and thus are not being considered. On the other hand, the technological side can learn what are the key requirements for industrial applications and what product developer require."
CERN Scientist

Pattern 3 – Identification and acquisition of potential collaborators: Another positive side effect of the conducted TCL projects was the identification of potential collaboration partners to the consortia. Those partners are needed to help with the actual development of technological solutions. While the consortia had strong competences in basic research and some development capabilities, they were proactively looking for partners helping with the manufacturing of the solutions:

"No one, except a particle collider, needs a 16 Tesla, 15 m long and 80tons heavy superconducting magnet. Especially not 5000 of them. …[…]…. Worldwide, there are probably 5 companies capable of producing those magnets. But why should they collaborate with CERN and dedicate all of their manufacturing capacities to one single customer? As a customer, we are not very attractive. We need a great quantity of highly specialized products, but only in 20 years from now and only once. To be attractive, we need to be able to tell them about other potentially attractive applications outside of CERN. This is how we might get them interested in working with us."
CERN Scientist

Obviously, the TCL projects were recognized as a strategy to identify and acquire potential collaborators. By presenting them potential market opportunities to the highly specialized solutions they were asked to develop for and in collaboration with CERN, it became easier to convince the industrial partners to enter a joint venture. Interestingly, the open innovation intermediary's teams were considered important in the process of approaching and convincing potential collaboration partners from the industry:

"I had been trying to get in contact with ThermoFisher for quite some time, without great success. It was the WU project team that managed to reach them and to create interest in a collaboration. ThermoFisher then even became a partner in the STREAM consortium. I guess, the university background and their neutrality allowed the WU team to get access to ThermoFisher".
CERN Scientist

This statement highlights an important functionality of an external open innovation intermediary in the course of *TCL* projects: Obviously, they were seen as a neutral third party which seemed to be a benefit in contacting and obtaining information from a wide range of sources.

Long-term project outcomes

Pattern 4 – Gaining TCL-related methodological competences: A very important motive of the consortia members to have an external open innovation intermediary organize and manage TCL projects was to gain methodological know-how through the interaction. Several of the interviewed project owners reported such learnings. For example, one corporate employee remarked that after having been involved in a series of externally conducted TCL projects, he had been able to employ elements of the approach when trying to find new application areas for technologies developed outside the ITN.

"Some of the tools and methods that I have learned during the TCL projects, I still use today back at my own company when looking for applications."
Company TCL project owner

This example illustrates two highly important aspects: Firstly, the owners of externally conducted TCL projects can indeed develop TCL-related project capabilities, despite the fact that they simply observe the activities of the open innovation intermediary. Secondly, those newly acquired competences can be transferred to other projects, in this case even to other organizations, illustrating a perfect example of "project-to-organization" learning.

In addition, two of the scientists interviewed reported that gaining experience with the method was of great help when writing project proposals, as increasingly, also scientific research projects have to include a technology transfer and commercialization strategy (see pattern 2). Again, this observation can be interpreted a case of "project-to-organization" learning, since the newly acquired knowledge about how to plan and implement TCL projects was applied to a new task within the focal organization CERN.

Learning about the method and its application mainly took place through monitoring the process and through interaction with the external intermediary during both official and unofficial meetings. Additionally, the comprehensive documentation of the conducted TCL projects, including information on the individual steps taken to reveal the technology's core benefits, to search for analogous application fields, and to rank these fields has been identified as an important element in learning about the method and in replicating the hole approach or parts thereof after the conclusion of the project.

"I can use the report to get suggestions on how to do myself what was done by externals. The report was comprehensive, including the methodology, and that is of great help."
Company TCL project owner

Pattern 5 – Developing boundary-spanning competences: Besides methodological know-how, the project owners also seemed to develop boundary-spanning competences, a highly relevant TCL-related project capability. More specifically, the interviewees reported that the initial TCL project contributed to a better understanding of the different perspectives of engineers and scientist on the one hand, and business developers and managers on the other hand. One respondent remarked that while he is used to talking with the R&D departments of potential partner firms, after a series of TCL projects, he now feels more capable to talk also with the business developers, who are more concerned with potential applications rather than detailed technical descriptions. Better understanding the perspectives of actors from other disciplines, as well as developing the capability to communicate with them, as a CERN scientist put it, in "*their language*" were both considered important competences needed for subsequent TCL projects within the ITN and future TCL activities. They increase the likelihood to successfully acquire partners from industry (see Pattern 3) and to develop valid technology roadmaps (see Pattern 2). Summarizing these insights, the development of boundary-spanning competences seems to be a project capability that builds over time through project-to-project learning. It was also considered a competence with high value beyond the current ITNs, again indicating a case of project-to-organization learning.

Those boundary-spanning competences also included the project owners' awareness regarding their own functional fixedness and competences to overcome it:

"I really learned a lot through the first two projects, in terms of language and what is important. Concepts such as user benefit and functional fixedness are things that I quickly identified in myself or started to internalize it. There was definitely a thought-process."
CERN Scientist

The interviewees considered learning to overcome their functional fixedness a necessary pre-condition to successful TCL projects in the future. Only if they were able to "*…look outside of the box…*" (Company Project Owner), they would be able to identify far-analogous, new applications and potential collaboration partners.

Another important learning for the project owners was the importance of looking at their technologies from a user's perspective. Learning about identifying and communicating user benefits happened especially in the pre-project phase, when the firms and institutions prepared to describe the technology to the project team of the external intermediary, whose members did in most cases possess no scientific or technical background. The ability to a technology's benefits from a user's perspective seemed to be predominantly a case of within-project-learning, since benefits relate to a specific technology and thus can hardly be transferred to other projects. However, respondents that had participated in a series of TCL projects, remarked that the generic, underlying logic of translating technological features and specifications into benefits was an important take-away. In subsequent TCL projects, this specific task appeared to be much easier, indicating economies of repetition and project-led learning.

Barriers to short-term project outcomes

Pattern 6 – Unclear project goals: While in general the interviewees were very satisfied with the immediate outcomes of the externally conducted *TCL* projects, they identified a number of barriers to short-term success. One problem encountered most frequently was a lack of clear direction and goal definition. A representative of a company within the consortium put it like this:

> "From our side it was not good that we did not clearly define where we want to go, what we can accomplish with this project. The people I worked with back at my company and who were not directly involved in the project did not understand the method at all. An introduction for the technology partner would be good to check whether the format in which the projects are conducted is suitable."

This statement points to a very specific problem: The project owners within the consortia do not only act on behalf of their consortium, but also on behalf of their company. While colleagues within the consortium were well informed about the scope and approach of the TCL projects, colleagues from the project owners' actual companies were not. The interviewee also indicated that it would have been helpful to get all stakeholders with a potential interest in the project on board by having the open innovation intermediary explain its approach to all of them, not only the directly involved persons.

The importance of this aspect became visible in other statements as well. The interviewees explained that colleagues in their companies, but outside of the consortia, were highly interested in the TCL projects and their potential outcomes. However, because they lacked detailed information on the open innovation intermediary's plan and approach, they expected somewhat different outcomes to what was actually delivered:

> "Make clear what cannot be done right in the beginning. To better define the project, that was a clear learning."
> CERN Scientist

> "Discussing the expectations in the beginning of the project is important, as it allows to work towards the goal in a more focused way. If the goal is to find new application fields, almost irrespective whether entering them can be done or not, it should be made clear. Or, if the goal is, I have already two possible applications in mind, let us see which one is more suitable, then this should also be communicated clearly."
> CERN Scientist

Summarizing these insights, the key learning has been to place emphasis on the first phase of the project. This requires investing time in preparing the participants – as well as their colleagues outside the consortia – and discussing the project scopes and parameters.

Pattern 7 – Lack of a company-internal perspective: A clear definition and discussion of guidelines can also help to alleviate another issue that has been mentioned: Being external to the organization and providing a fresh outlook is a main advantage of external open innovation intermediaries. At the same time, this means that they might lack the in-depth understanding of the organizations' rules, policies and procedures. One interviewee discussed this problem in detail, as the intermediary identified a promising application field and connected the project owner (CERN) with a potential customer from this field. Due to internal restrictions that do not allow CERN to cooperate with firms that are suppliers to armed forces, the initially promising opportunity was not pursued.

> "What has been identified as the most promising application, did not necessarily fit with our policy. At the end, we could not and did not want to pursue this opportunity."
> CERN Scientist

Another problem caused by the lack of a company-internal perspective as well as the lack of deep technological insights on the open innovation intermediary's side is a relatively high uncertainty about the applicability of some of the project outcomes. It has been voiced in the interviews that the project duration of 3 to 4 months allowed to identify promising application fields, but did not provide enough time to identify potential obstacles, especially for complex technologies that are still far from any use case.

> "The use cases are very specific, it is almost impossible to identify if it is really feasible and what the timeframe would be within the typical project duration. It is also hard to impossible to identify any gaps, be that a technology gap, a performance gap, a cost gap, or an acceptance gap. It takes actually a long time to be able to confidently state here is a technology with a realistic estimate for a specific use case over the next 5–10 years."
> CERN Scientist

Barriers to long-term success

Pattern 8 – Project owners without management responsibilities: For a long-term success and a transformation of an organization's capabilities, it is required to disseminate the results of the open innovation projects as well as to increase the knowledge and awareness about the methods to a wider audience. Obviously, the project owners do play a crucial role here since they are the ones that have collected first-hand experience with TCL projects. In cases where the project owners had some managerial responsibility – even if they were scientists or engineers by training – they were willing to learn about TCL activities and also passed their newly acquired know-how on to their colleagues. If the project owners were scientists without management tasks, they were much less interested to learn more about the method and embrace a more user-oriented view. Consequently, they did not develop a great amount of TCL-related project capabilities that they could have shared with their colleagues and disseminated within their organizations. One interviewed scientist stated this aspect quite drastically:

> "I see it with the students in the EASITrain project. There is a sort of rejection; they do not want to hear about it anymore. They say, my *job is something else, I already have enough work, my life is already complex enough trying to figure out how to liquefy helium in an energy-efficient way. I cannot also spend time to think about who can use it to sell party balloons in a cheaper way."*
> CERN Scientist

The major learning here is that the project owner should not only possess technology-related knowledge, but also hold a management position when collaborating with an external open innovation intermediary. While the technology-related knowledge is a necessary precondition to be able to explain the technology to the project team, it is not a sufficient qualification to ensure a long-term project outcome in terms of development of project capabilities that can diffuse throughout the organization. Since TCL activities are meant to be an ongoing strategic effort that require a long-term commitment, scientists who do not see themselves participating in such activities in the long run, have no incentive to acquire the respective competences.

Discussion

This research set out to explore if and how externally conducted TCL projects provide value to the focal organization. We focused on short-term, project-related outcomes of TCL projects as well as their contribution to building TCL-related project capabilities. In addition, we wanted to shed light on the most important organizational barriers to achieving these outcomes.

Our in-depth case study yielded new and interesting results, that contribute to theory and the practical realm alike. Based on a systematic analysis of primary and secondary data, we found eight patterns that fall within the scope of our research questions. Firstly, we found evidence that externally conducted TCL projects actually are a viable means of technology transfer for research organizations. Within the ten analyzed projects, an average of 21 commercially viable and technologically feasible market opportunities for the project owners' technologies were identified. In addition, the TCL projects also helped to come up with valid technology roadmaps for the focal organizations, as well as with the identification and acquisition of potential collaborators. Secondly, our results also indicate that project owners in externally conducted TCL projects indeed were able to build TCL-related project capabilities, enabling them to employ TCL activities themselves without the help of an open innovation intermediary. Thirdly, we were able to identify the most important barriers to short- and long-term outcomes of TCL projects, which are unclear project goals, the open innovation intermediary's lack of a company-internal perspective, as well as staffing the TCL projects with owners lacking management responsibilities.

Theoretical contributions

These findings contribute to the literature on both open innovation and project-led capability building. In the field of open innovation, scholars have long been calling for more research on the question of how to realize the potential of this new approach to innovation (West & Bogers, 2017; West et al., 2006). Particularly, additional insights on the phenomenon of outbound innovation are needed. Our work heeds this call and offers insights into best practices to strategize and organize a specific outbound open innovation activity: TCL. The results of our case study show that organizations, lacking the necessary TCL-related competences themselves, can outsource those types of activities and thereby yield satisfying results. We found that in our case, number and novelty of identified application fields to the focal organizations' technologies have actually exceeded the project owners' expectations. This finding is in line with results found in the domain of the lead user research. For example, Lilien et al. found externally sourced, lead user-generated ideas to be superior over internally generated ideas with regard to their novelty and originality. On the other side, the lead user-generated ideas were considered less feasible and much harder to implement (Lilien et al., 2002). Our research offers a sound explanation for this observation: The open innovation intermediary – just like the lead users in the Lilien at al. study – lacks a company internal perspective. External actors are less aware of organizational rules, policies, and procedures. In addition, the project team of the open innovation intermediary (in contrast to a lead user) did not have a deep understanding of the technology that was to be leveraged. Both aspects have been described by our interviewees as barriers affecting the efficacy of externally conducted TCL activities. Thus, from a project management point of view, our results highlight the importance of the initial project phase (the initiating and planning phase as well as the first step in the execution phase, see Fig. 2). This phase does not only include the internal preparation for the collaboration with the open innovation intermediary, e.g., the documentation of the technology, which has previously been identified as a major challenge for outsourced open innovation projects (Sieg et al., 2010). It also includes the creation of a shared understanding about the goals and guidelines for the project, helping to reduce the problem of a lack of an internal perspective of the open innovation intermediary.

Interestingly, our research also points to two short-term outcomes of externally conducted TCL projects that have – to the best of the authors' knowledge – not been described in the open innovation literature so far. Firstly, the identification and evaluation of far-analogous application fields yielded in insights highly valuable to the project owners with regard to their further research and development processes. Gaining in-depth insights into the requirements of future users from completely new domains helped the project owners to focus on the most relevant attributes and functionalities when working on their technologies. These "technology roadmaps" can thus be considered a valuable asset to technology-driven organizations like CERN. In addition, in the course of the TCL projects, previously unknown and/or unapproachable collaboration partners with skills complementary to those of the consortia were identified. A major success factor in achieving this outcome was the fact that the projects were conducted by a "neutral" party, i.e., the open innovation intermediary. This finding indicates that externally conducted TCL projects might help in setting-up or extending open innovation networks and ecosystems (Adner, 2006; Adner & Euchner, 2014; Oh, Phillips, Park & Lee, 2016). Our findings also contribute to the ongoing discussion about open innovation intermediaries (Diener et al., 2020; Radnejad et al., 2017; Randhawa et al., 2017), especially regarding their role as matchmakers (Katzy et al., 2013) and their effects in science- and technology-based settings (Sieg et al., 2010).

In addition, our research also adds to the literature on organizational learning and more specifically project-based capability building (Brady & Davies, 2004; Davies & Brady, 2016). Most of the existing literature dealing with project-based learning claimed the necessity for the focal organization to move into a new type of project itself in order to gather relevant knowledge and experiences, which specific project capabilities consist of (Defillippi & Arthur, 2002; Prencipe & Tell, 2001). The current paper challenges this view and makes a strong argument for the possibility of mediated project capability building via externally conducted projects: In our case study, we found that within-project learning, project-to-project learning, as well as project-to-organization learning about the TCL approach occurred, despite the fact that the projects were conducted by an open innovation intermediary. These learnings resulted in a wide variety of TCL-related project capabilities with the project owners, allowing them to conduct TCL projects and similar activities even after the end of the ITN. More specifically, we have found evidence that project owners, after having participated in the TCL projects, were better prepared to analyze the technology from a user's perspective and understand the technology's use benefits. This new capability makes it much easier for the project owners to identify, and evaluate new application fields. Based on the awareness about the technology's benefits, analogies to application fields can be drawn and ideas can be generated where similar problems as in the target market exist and thus the technology's benefits are relevant, too. An increased understanding of user benefits and the view typically taken by business developers also allows for a better communication with non-technical staff from external organizations. This capability increases the ability to leverage the networks and contacts built up during the TCL projects. In addition, the interviewees in our case study reported that they now feel more confident to approach and convince potential partners from industry with complementary assets and skills. This means that they feel better prepared to mobilize (external) resources to address an opportunity. Furthermore, we saw that organizations also managed to mobilize internal resources after the end of the externally conducted TCL projects, and have performed steps to continue with identified new market opportunities. Two interviewees reported that they utilize the skills acquired during the TCL projects when writing grant applications. They seem to consider TCL activities as part of their organizational repertoire of strategically important activities. We have not seen, however, any indication of organizational changes to facilitate the project owners' organizations to effectively and efficiently conduct TCL projects themselves in the near future. All these new competences are considered important TCL-related capabilities, and they have been acquired through series of externally conducted TCL projects.

It has to be mentioned, though, that the development of TCL-related project capabilities at the operational level via externally conducted TCL projects heavily depends on who acts as project owners on behalf of the focal organization. We found that mere scientists without management responsibility, that had been appointed to participate in the TCL projects, were not motivated and thus likely to learn about the TCL method. This, obviously, prevents organizations from acquiring TCL-related project competences.

Managerial contributions

This research project also offers some clear implications to managers who want to outsource their TCL activities to an open innovation intermediary. First and most importantly, our results show the need for an alignment of the TCL projects' timeframe with the timeframe of the organization's overall product development process. While an individual TCL project, i.e., the identification and evaluation of new application fields for a technology and a first strategy to enter them, can be completed in the timeframe of 3 to 4 months, the involved firms and research organizations see this as part of long-term ongoing product development processes. Especially with science-based technologies, it can take years between the start of R&D activities to the emergence of the technology in a finished product. Consequently, TCL activities and thus the collaboration with the open innovation intermediary – at least in the course of initial vanguard projects – should probably not be limited to 3 to 4 months in order to actually support the commercialization processes of the focal company.

A second, actionable advice based on our data is to staff the project with a project owner that has both, technology-related knowledge but also management responsibilities. While the short-term outcome of the project does not seem to depend on this measure, the long-term outcome, i.e., the development of project capabilities, does. Scientists are generally less interested in the management side of TCL activities, which prevents them from pro-actively trying to learn about it. If the focal organization lacks managers with a technological background or scientists with management responsibilities, a viable option would be to install an interdisciplinary team of two project owners.

Last but not least, we found the initiating and planning phase as well as the first step within the execution phase of utmost important to the success of externally conducted TCL projects. Besides staffing the project team from the project owner's side, a first meeting with the project members from the open innovation intermediary in which the technology is presented to the team in person, is crucial. Only if the project team gets a valid idea about what the technology is able to do, i.e., which problems it solves, the team will be able to derive the benefits of the technology. Those benefits are the basis of a successful search for and evaluation of commercially viable and technologically feasible application fields.

Limitations and further research

As any empirical research, this case study suffers from some specific, methodological limitations. Our research investigated a broad and important phenomenon, however, in the very narrow context of large-scale research organizations. Thus, some of the insights are very specific and might not be easily generalized. For example, Pattern 8 (project owners without management responsibility) might not occur quite frequently outside of the research domain. In many companies, TCL projects will be very likely staffed with business developers that usually do have managerial responsibilities. Further, the identification and acquisition of potential collaborators might be much more of a problem to large research organizations than companies. Future research might want to look into whether or not the patterns identified in this case study hold true for other contexts as well.

Another potential shortcoming of this study, closely related to the problem mentioned above, is the limited scope with only one partner and one intermediary. Although we looked at CERN, an organization that had hosted three ITNs featuring a total of ten TCL projects, we cannot pretend to have conducted a comparative, multi-case study. We expect future research to investigate a larger number of different organizations and intermediaries, both to check for the robustness of our patterns, but also to uncover additional insights that are not present in the current case. Another potential avenue for future research is to dive deeper into the mechanisms of collaboration between the partners. Prior research has shown the important role of trust in collaborative efforts such as new product development (Bstieler, 2006) and university-industry collaborations (Bstieler, Hemmert & Barczak, 2015). Thus, investigating factors such as communication behavior, shared governance or perceived conflict can further add to the understanding of how to organize and conduct effective outbound open innovation projects involving multiple partners.

Declaration of Competing Interest

Conflict of Interest As this paper was co-authored by a member of the guest editor team, the review and decision process was managed by the editor-in-chief of the International Journal of Project Management.

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Appendix

Questionnaire

(1) What is your role/position within your organization? What was your role within the TCL projects?
(2) Who else was involved in the TCL projects and in what role? Why?
(3) Why have you decided to go for/participate in TCL projects? What did you expect from this type of project?
(4) Why did you opt for an external intermediary to conduct this type of technology valorization approach? What are the advantages of having externals work on TCL projects, what are the disadvantages?
(5) How did you select on which technologies the external TCL approach should be applied?
(6) How did you actually benefit from those projects? How did the projects provide value to your company? What were the most important results/insights for your organization, both on the actual project level but also for the organization overall?
(7) From your perspective/experience: What are the most important success factors in managing/organizing these projects? How can an organization ensure externally conducted TCL projects become a success? What mistakes should be avoided?
(8) *Additional questions (if not already answered by the interviewee)*:

What did you learn from participating in those projects?

Were there any surprising insights, e.g., newly identified benefits or application fields that you had never thought of before?

Which capabilities did you acquire throughout those projects?

Would your organization be prepared to conduct such projects internally/in-house?

In case of repeated TCL projects: which learnings from prior projects were most important for the success of follow-on projects?

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