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ORIGINAL PAPER

When and how often to externally commercialize technologies? a critical review of outbound open innovation

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Abstract Since the 1990s, external technology commercialization (ETC) has become increasingly relevant in business management practice and the academic literature. Frequently, ETC is praised as highly important and is often even considered an important competence of a progressive firm. To date, research has mainly focused on the opportunities and advantages of ETC, while risks and costs tend to be ignored or downplayed. This paper aims to review ETC critically. We stress that ETC might not only cause operating costs but also requires additional human resources. From a strategic perspective, we propose that ETC may result in the loss of competitive advantages through the disclosure of internal knowledge (or areas the firm is working in) or through the suboptimal allocation of R&D resources, and thereby affects a firm's performance negatively. Finally, we propose specific implications for management and research on when and how often companies should practice ETC, and illustrate related practical experience by a case study. We thereby propose an inversely U-shaped relationship between ETC's intensity and the firm's profit contribution.

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1 Introduction

Today's rapid technological change evokes new challenges for technology and innovation management. Firms see themselves exposed to increasing development efforts, higher demands on quality, and increasing complexity on the one hand as well as decreasing availability of resources and shorter innovation cycles on the other. This conflicting development increases the pressure on many firms and is the main reason for the fundamental strategic reorientation in the field of technology and innovation management (Cassiman and Valentini 2016; Enkel et al. 2009; Tschirky et al. 2004). For many firms as well as researchers, this reorientation is evident in the opening of a firm's boundaries to attain people and ideas from outside to counter these challenges (e.g. Chesbrough and Garman 2009; Dahlander and Gann 2010; Enkel et al. 2009).

Through the rise of the open innovation approach, which was characterized by Chesbrough (2003a), more and more firms recognized that competitive advantages can be generated by opening the technology and innovation process, which is the approach of external technology commercialization (ETC)—considered as outbound open innovation by Chesbrough—to leverage their in-house R&D (Chesbrough and Brunswicker 2014).

Research in the past has primarily focused on addressing the opportunities, advantages, and, in particular, monetary effects of ETC and recognized it as a "must do" in a firm's action portfolio, while risks tended to be ignored or downplayed (Frishammar et al. 2015; Hung and Chou 2013; Lichtenthaler 2015). Although research has begun to raise awareness about the negative aspects of open innovation in general by addressing, for instance, the "paradox of openness" (Laursen and Salter 2014), it has failed to deliver a differentiated answer for firms that do not focus on ETC and just want to use this approach to improve their competitive position or their balance sheet. Does the potential of ETC justify its execution for these firms?

The purpose of our paper is to address this absent differentiated and holistic view in ETC literature to clarify the strategic question of when to use ETC for firms that do not focus on ETC and to sensitize researchers as well as practitioners that the advantages of ETC do not always overcompensate its disadvantages. Thus, the first distinct contribution of this paper is the combination of the insights from prior studies and practical examples to provide a critical and holistic view on the use of ETC. Based on these insights, the responsible managers will (1) be better aware of the strategic and operational risks involved with ETC and can therefore consider these at an early stage in the corporate planning and strategy process, and (2) have a guide for successfully managing ETC in different situations. Second, by combining the ETC insights from prior studies with the financial performance of a company, we also illustrate the overall financial impact of ETC depending on the usage intensity of ETC. We additionally extend theory on ETC by proposing an inversely U-shaped relationship between the

intensity of ETC and its firm's profit contribution. Third, we provide orientation for when to use ETC, which are based on strategic and financial evaluations. According to our thorough literature review, there exists no comparable overview of strategic options on this topic.

This article is structured as follows. First, the conceptual fundamentals are explained. Based on these fundamentals, the advantages and disadvantages of ETC are discussed and are connected to the financial impact dependent on the ETC intensity of a firm in the three sections that follow. Before providing a short summary of the findings and propositions for future research, we suggest when ETC should be practiced. A case study illustrates our claims and the paper is finalized by the theoretical implications.

2 Conceptual fundamentals

Although research in the 1990s and earlier already pointed out the need for an increased external focus on technologies and a more outward-looking orientation regarding their R&D and New Product Development (NPD) (e.g. Rothwell 1992; Trott and Hartmann 2009), it was Chesbrough (2003a) who managed to capture and explain the fundamental rethinking of many firms and managers at the beginning of a new era in the Twenty first century and transported the idea of "open innovation" to a broader audience. Chesbrough (2003b, p. 35) described this idea as "the fundamental ways in which they [firms] generate ideas and bring them to market—harnessing external ideas while leveraging their in-house R&D outside their current operations." In this concept of open innovation, ETC represents the outbound stream as opposed to external technology sourcing (ETS), which represents the inbound stream of open innovation. Both streams can be executed separately as well as simultaneously; the latter is also called "coupled process" (Chesbrough 2011). Before we examine the scientific debate on ETC, we introduce and explain the respective research streams inbound and outbound to provide a basic understanding of the theoretical fundament. In line with our study's purpose, we only address the use of technologies.

2.1 Inbound open innovation and external technology sourcing

ETS determines the internalization of technology that was generated outside the own firm (Chesbrough 2011); the origin of the technology has thereby no relevance. It can be sourced by firm acquisitions or collaborations with suppliers, customers like lead-users (Von Hippel 1986), competitors, technological alliances (Kim and Choi 2014) or research institutions from the same or a different industry. The internalized technologies are used for research, development, and modification of the firm's own innovations.

The external sourcing of technology is already established in many firms and has been found to be an unerring concept for successful innovations (Inauen and Schenker-Wicki 2011; Laursen and Salter 2006; Dowling and Helm 2006). Two examples of this are Vodafone and Cisco Systems. Instead of conducting basic research, Vodafone uses this approach for its R&D activities by collaborating with external knowledge-pools, such as universities (Stüer et al. 2010). Cisco Systems

prevailed against the strong competitor Lucent Technologies with the aid of ETS. Initially, Cisco lacked sufficient resources for R&D activities, while Lucent Technologies possessed those necessary to conduct all R&D activities internally. However, through the external sourcing of innovations, know-how, and technologies on the market, Cisco was able to compete against one of the most innovative firms worldwide without high R&D efforts (Chesbrough 2003b).

Both examples illustrate that firms can profit from a counterpart from whom they acquire or take technologies in the form of ideas, know-how, innovations, or licenses. While such "technology" cooperations have existed for several decades, external technology commercialization has gained considerable importance since the 1990s (Lichtenthaler 2007; Tschirky et al. 2004).

2.2 Outbound open innovation and external technology commercialization

ETC describes the external commercialization through sale or licensing of internally developed technologies to customers outside the own firm. Thereby, the transfer can take place between firms of the same industry as well as between firms of different industries. The customer, in turn, uses these transmitted technologies for research, development, and modification of his own innovations (Chesbrough 2011; Easterby-Smith et al. 2008; Enkel et al. 2009; Fosfuri 2006).

Since the beginning of the Twenty first century, an increased number of firms have conducted external technology commercialization to realize strategic and monetary goals. Motorola, for example, generated revenues of over 10 billion USD through the licensing of its advanced technologies in the fields of software, microchips, and production tools, while at the same time, it was able to foster the spread of its technologies over the industry (Kline 2003). Another example of the successful implementation of ETC is EOS GmbH, the global market leader in the field of additive manufacturing and industrial 3D-print technology. The firm possesses more than 700 patents—these patents as well as its technologies are licensed to competitors with the aim of setting them as industry standards and, accordingly, being able to influence future developments on the market (TOP 100 award website 2013). More and more, firms are moving away from an "exclusive value perspective" on their intellectual property and are instead seeking to tap the promising financial and strategic value of their core technology assets (Kline 2003).

2.3 Different types of ETC

However, before we discuss the advantages and disadvantages of ETC, we need to have an understanding of what ETC could look like. ETC cannot only be practiced as a "cash machine," for example, through licensing; it can also be executed in terms of cooperations, partnerships, joint ventures, or by the establishment of a spin-off. In the course of a strategic reorientation, Bayer AG officially announced that the chemical operations and plastics activities would no longer be part of the core business. Because Bayer did not want to completely abandon this division, it outsourced it in the form of a spin-off—the now worldwide successful chemical firm Lanxess AG (Lanxess AG firm website 2017), which was founded in 2005.

This example illustrates one of several options for the execution of ETC. These options can be classified into the subordinate categories of joint use such as strategic or technological alliances (e.g., Bouncken et al. 2016; Kim and Choi 2014), licensing (Gleave and Feess 2016), and technology sales (Birkenmeier 2003; Ford 1985; Granstrand 2000). Figure 1 shows a detailed classification of the types of ETC in the three most commonly used categories in literature.

As all presented forms of ETC have the core elements "transfer of ideas," and "technologies or know-how to competitors or other firms" in common (see Fig. 1), we won't address their specific characteristics and their driving forces in this paper's general critical assessment of ETC.

Next, we will first describe the opportunities and threats of ETC and connect them to the financial performance of the company before we conclude with the financial curves dependent on ETC's intensity in Sect. 5.

3 Advantages and opportunities of ETC

Due to a continuous shortening of technology and product life cycles, the need to incorporate new technologies in existing product solutions, and the chance to step into new business fields with new technologies, firms have less and less time to

	Birkenmeier 2003	Granstrand 2000	Ford 1985
Joint use	Joint-Venture	Joint-Venture	Joint-Venture
	Strategic alliance	R&D co-operation	
Licensing	To other regions	Licensing	Licensing
	To other industries		
	To competitors		Supplier
	To suppliers		
Technology sales	Technology sales	Technology sales	Technology sales
	Patent sales	Setting up of creative corporations	
	Spin-offs		
	SBU sales	Outsourcing	

Fig. 1 Types of external technology commercialization

develop new technologies and compensate R&D costs with their new products and services (Chesbrough 2007).

One vehicle for solving this dilemma is the use of ETS and ETC. On the one hand, ETS enables the *lowering of the constant rising development costs* that result from the growing complexity of the products, the increasing development effort, and the demand for higher quality and variant diversity. In addition, *time can be saved* because knowledge, technologies, processes etc. already exist on the market and do not need to be newly developed in a time-intensive and cost-consuming way. On the other hand, the sunk costs for the development of "waste technologies," namely technologies that are of no use to the firm, can be reduced or even lucratively transferred by ETC on the market, e.g., through licensing to capture additional value from this knowledge (Dowling and Helm 2008; Lichtenthaler 2010; Gleave and Feess 2016) and thereby bring benefits to other firms (Chesbrough 2007). As a consequence, the decreased market revenues due to shorter product life cycles and price pressure can be compensated through ETS and ETC. In line with this argumentation, firms that open their innovation processes, through ETS or ETC, benefit from the resulting additional value.

Firms do not just use ETC to reduce sunk costs; they also expect to *profit* through its use in the form of licensing or technology selling revenues (Lichtenthaler 2009; Chen et al. 2011; Gleave and Feess 2016). IBM is probably one of the most well-known examples that benefits from these positive material effects of ETC by generating a high volume of its sales through licensing revenues (Enkel et al. 2009). In 2000, revenues from granting licenses represented around 20% of IBM's net sales (Kline 2003).

In addition, firms expect to achieve *strategic advantages* through ETC. The exchange of and access to external knowledge, which comes from the contact to potential technology buyers and their technology know-how, stimulates the internal creation of new knowledge, e.g., through new combinations of technologies (Cheng and Huizingh 2014) and helps in getting on the market with new products faster (Enkel et al. 2009; Faems et al. 2010). The higher degree of innovativeness and pace of innovation that arises leads to a more efficient and more effective innovation process (Enkel et al. 2009) that in turn increases the corporate profit by the internal use or external commercialization. Thus, the strategic advantage of practicing ETC lies in gaining access to allies or technology partners and their knowledge (Cheng and Huizingh 2014).

When a firm successfully establishes its technology as an industry standard, the future sales of its own products and services will be secured (Kline 2003; Koruna 2004; Lichtenthaler 2006, 2009). ETC through licensing can thereby serve as a *catalyst for sales.* This is especially relevant in industries with dominating network effects because firms in such divisions are more successful the more firms utilize their technologies. A prominent example in this context is the VHS format of the firm JVC. The firm successfully established its technology as an industry standard despite their competitors having, to some extent, better technologies or cheaper products. This was only possible because of the fast enforcement of this format through licensing (Koruna 2004; Trott and Hartmann 2009).

Cheng and Huizingh (2014) also recognize a positive effect of ETC on *innovation performance*. This finding is in line with Lichtenthaler (2009), who found an overall positive effect of ETC on firm performance, in particular in an environment with high technological turbulence, high transaction rates, and high competitive intensity.

To sum up, the previously discussed network effects may improve the effectiveness of ETCs over time, which will be reflected at first in a slight increase in ETC revenue and then a stronger constant increase in revenue by an increase in ETC's intensity (see the ETC revenues curve in Fig. 2 in Sect. 5).

The positive effects of ETC should, however, not suppress the fact that there are also many pitfalls and threats from applying ETC. In most cases, unfortunately, the discussion about ETC ends at this point with the conclusion that ETC solves nearly all problems and challenges in the field of R&D and innovation management. Therefore, we highlight the negative consequences of external technology commercialization in the following section.

4 Disadvantages and threats of ETC

West and Gallagher (2006, p. 320) asked the question "why would firms contribute resources, including IP, to projects that will benefit others, including their competitors?" This already indicates the risks involved with ETC. Nevertheless, most authors claim that the opening of the innovation management results in considerably higher returns on innovative capacity and intellectual property, and thereby abandon the complete control over their innovation and R&D activities.

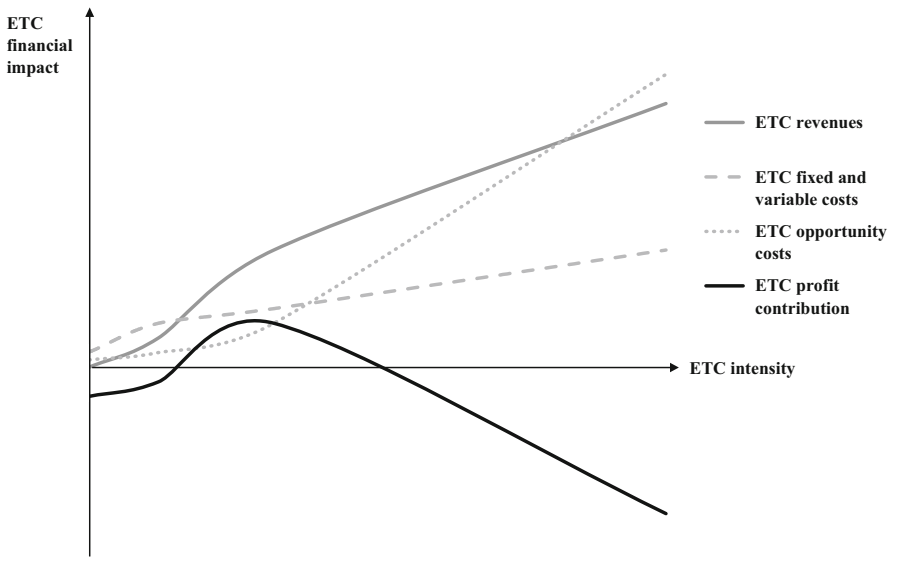

Fig. 2 Illustration—ETC's intensity and its financial impact on the firm

This paradoxical phenomenon will be addressed in this section along with a critical perspective on ETC. Thereby, the risks from its potential negative consequences for costs, business performance, know-how drain, and abandonment of competitive advantages as well as the loss of the core business focus are highlighted in the following to provide a holistic view of ETC.

4.1 ETC's execution and implementation expenses

Chesbrough and Crowther (2006) argue that firms create numerous ideas and innovations during the course of their R&D activities that do not have any benefit for the developing firm. Following the open innovation approach, such ideas and innovations can be enhanced and put on the market in order to reduce sunk costs. This argumentation sounds highly convincing but often ignores, that the implementation can be highly resource intensive, e.g. by providing a screening scheme for potential buyers, and causes transaction costs, e.g. for the evaluation whether or not to externalize even a not fully developed R&D project (Frishammar et al. 2015). For a reasonable external commercialization of technologies, the evaluation of all its relevant applications is necessary (Lichtenthaler 2006). This requires time and *specialized employees* (Faems et al. 2010). After the identification of a partner and an adequate application for the specific technology, extensive negotiations and elaboration of contracts follow. Furthermore, control measures must be implemented to minimize opportunistic behavior, to verify compliance with the transfer agreements, and to value the advantages and the success of the transfer (Lichtenthaler 2006). A dedicated management division, frequently called Licensing Group or Technology Transfer Group (Bianchi et al. 2011), is often necessary for these tasks (Faems et al. 2010). The thereby incurred transaction costs further stress the balance sheet (Kale et al. 2002). These transaction costs can be reduced partly when companies use technology sourcing platforms such as ideaCONNECTION or INNOCENTIVE (ideaCONNECTION 2017; INNOCENTIVE 2017). These platforms not only connect problems or challenges of organizations with solvers but also connect sellers (e.g., technology licensor) with buyers (e.g., technology licensee). Although these platforms thereby reduce the search costs for new partners, they still cannot cover the identification of the partner fit, contract negotiation, technology implementation, and control mechanisms. For building up commercialization know-how and network structures (e.g., to sell technologies), and for introducing and implementing ETC in the processes of the firm, a minimum budget is required, and a strong increase in fixed and variable costs can be expected for continuing with the first ETCs. Thus, we assume that with a higher ETC intensity, the fixed and variable costs first increase strongly and then increase less strongly because of the fixed cost degression effects. This is illustrated by ETC's fixed and variable cost curve in Fig. 2 (Sect. 5).

Prior studies on ETC do not address whether ETC really provides an advantage in terms of time and cost because up to now, it is mainly the technology development efforts that have been contrasted with the returns of ETC or with the potential profit loss if a firm were to cease implementing ETC (Faems et al. 2010).

4.2 Loss of competitive advantages

This issue begs the question of whether and how ETC affects business performance. Thereby, the applied *strategy* also plays an important role in determining if ETC could be successful or not. Interestingly, firms that only focus on ETC without having a strategy for ETS generate a lower profit margin of their operating income than firms that prefer neither (Chesbrough 2007; Lichtenthaler and Ernst 2007; Lichtenthaler 2009). In fact, empirical studies support the idea that practicing ETC and ETS simultaneously result in the highest profit margins (approx. 5–10% of the operating income; Lichtenthaler 2007). Cassiman and Valentini (2016), however, recommend a one-sided orientation, meaning either ETC or ETS, because they found a disproportional increase in R&D costs compared to the increase in sales through engagement in both in- and outbound activities. Research further suggests that an extremely open attitude towards ETC could have negative consequences such as higher profit setbacks, especially when competitive technologies are abandoned frivolously (Kline 2003; Laursen and Salter 2006). We illustrate this profit setback with a strong increase in opportunity costs at a higher level of ETC intensity because of a higher probability to selling an innovation that is needed later internally or a competitor is using it (see Fig. 2 in Sect. 5). As a consequence, the *loss of future competitive advantages* is a further significant threat from ETC. The threat exists primarily in the divulgation of strategic relevant technologies or knowledge to competitors, and could thereby weaken or even compromise the firm's own competitive position (Kline 2003; Laursen and Salter 2006). The greater the technological advance of a technology, the more uncertainty is involved with its potential role and benefit in the own industry's future. Some of Xerox PARC's former Spin-Offs that later became well-known firms such as Adobe or 3Com might illustrate how difficult it is to foresee the strategic and economic relevance of technologies and business models at the technological frontier (Chesbrough 2003a). Firms, however, tend to focus on the high revenues of these technologies, which often leads to a frivolous decision in favor of short-term profits (Lichtenthaler and Ernst 2007). This short-term perspective could endanger the survival of firms in the long run. Therefore, the *choice of technologies and know-how for ETC* is one of the biggest challenges in innovation and technology management (Dahlander and Gann 2010).

Dahlander and Gann (2010) further imply that technology-commercializing firms often do not have any awareness (incomplete information) of the profit and business potential the commercialized technology could deliver for external buyers or even competitors. According to them (Dahlander and Gann 2010, p. 704), "Competitors can be better positioned with complementary assets and production facilities to make use of the technological advance." ETC can thereby *strengthen the competition,* which in turn weakens a firm's own competitive position even though the technology or, rather, the knowledge seemed irrelevant at first glance. Even though these technologies are not directly sold or licensed to competitors, the external technology's customer could either become a competitor, perhaps because the selling firm did not recognize the technology's full business potential, or they could resell the purchased technology to the competition. Therefore, it is necessary

for the focal firm to not only protect its core knowledge, but also to protect knowledge that was not originally classified as core knowledge (Frishammar et al. 2015).

The threat in the choice of partners lies, in particular, in the risk of *divulgation of exclusive knowledge* because individuals in decision situations always decide what is best for their own profit (or best for their organization) regardless of disadvantages arising for their counterpart (Williamson 1973; Gleave and Feess 2016). In the case of ETC, this means that the behavior of both the commercializing and the purchasing firm has reciprocal consequences. Both parties are arranged in an interdependent relationship but simultaneously want to maximize their own profit. This indicates that the commercializing firm can never be certain of having eliminated the *opportunistic behavior of its partner* although additional contractual and non-contractual instruments were used (Helm and Kloyer 2004; Kloyer et al. 2007). The focal firm loses control over its knowledge and can only trust the partner to use the knowledge in a non-destructive way (Frishammar et al. 2015).

4.3 Loss of focus

Zook and Allen (2013) found that corporations that focus on their core business are the most successful ones. Huizingh (2011, p. 4) further shows that "Increased attention towards outbound open innovation […] may dilute the firm's focus at the expense of its customers." A too strong focus on ETC might result in short-term profits in terms of licensing revenues, but could also negatively affect the provided long-term value for customers by losing the focus on their needs. This prevents long-term success because the shift from customer-orientation to profit-orientation makes the firm lose its core business (Huizingh 2011). Although prior work has acknowledged some pitfalls of ETC (e.g. Frishammar et al. 2015), the prescribed harmful effects of conflicting goal-settings that often go along with the practice of ETC is a much more serious and systematic issue that has not yet been acknowledged despite their importance (Latham and Locke 2006).

To sum up, the resource-intensive execution and implementation expenses of ETC stop the employees involved from concentrating on the core business and the realization of new innovative activities for their firm for the sake of working on technologies that are, at first glance, not necessarily usable for the core business. Firms that reduce their focus on the core business may eventually lose value in the long-term because of their reduced customer relevance. These arguments are reflected in ETC's opportunity cost curve in Fig. 2 (Sect. 5), which shows at first a slight and then a sharp constant rise as ETC's intensity increases. We propose that firms should be engaged in R&D activities that are at a first glance unrelated to the core business but they should not be engaged too much. A clear dedication of a certain percentage of the R&D budget to these activities could prove helpful in getting a grip on both sides of innovation activities. This approach could be implemented and controlled as a specific ETC-project category in the process of formulating a technology strategy and allocating the R&D budget (Cooper and Edgett 2010; Wheelwright and Clark 1994; Dowling and Hüsig 2002).

5 How often to use ETC?

Although risks have rarely been considered to evaluate ETC in the past, opportunities and threats cannot simply be balanced. Instead, the question should be whether the potential of ETC justifies its execution, and how often firms that do not focus on ETC should use this approach.

To address the issue of how often to use ETC, we propose a graph in Fig. 2 that summarizes our findings by illustrating ETC's financial impact on the firm, depending on its usage intensity. We thereby address the fact that ETC's efficiency also depends on its execution intensity. The less ETC is practiced, the less experienced a firm is in matters of initiation, adaptation, and control of externally commercializing technologies. Furthermore, the risk that ETC might transfer potential competitive advantages directly or indirectly to the competitors is also increased by a firm's low frequency of ETC activities (Tschirky et al. 2004). When a firm commands only little desorptive capacity—the ability to commercialize technologies externally—it has neither experience in the identification of perfect partners nor adequate knowledge about potential applications of the commercialized technologies. According to Lichtenthaler (2006) this lack of experience is particularly a threat for firms where ETC is not included in the corporate and R&D or technology strategy. Following these arguments, it would appear at first sight that starting from a minimum level the more ETC is practiced, the higher the overall profit contribution of ETC for the firm is due to learning curve effects and fixed cost degression. However, our previous discussion has shown that this is only true to a certain extent. Figure 2 summarizes our findings from Sects. 3 and 4 by illustrating ETC's financial impact on the firm, depending on its usage intensity.

To sum up, we propose that a too intensive execution of ETC can turn the profit contribution of ETC to the firm negative, as illustrated in Fig. 2. These ideas lead us to suggest an inverted U-shaped relation between ETC intensity and its profit contribution to the firm.

6 When to use ETC

To address the issue of when to focus on ETC, we propose a decision tree at the end of this paragraph to illustrate the strategic decisions of a firm with regards to the ETC options for its R&D projects. In times of fast technological changes, it is good for firms to conduct R&D projects that focus on technologies that are at a first glance unrelated to their firms' current business field (Arzubiaga et al. 2017) however, we argued above that these firms still need to ensure that they do not lose their core business focus. These projects, which we call "business-unrelated" R&D projects, should run in parallel (not necessarily at the same place, e.g. Hüsig (2006) or Stüer et al. (2010) to the "business-related" R&D projects. This fundamental idea is based on organizational ambidexterity theory. Firms that engage in the exploration of new possibilities, for example, through "business-unrelated" R&D projects, and, simultaneously, in the exploitation of old certainties, which refers to

"business-related" R&D projects in our case, are likely to be successful in the long-run (March 1991; Raisch and Birkinshaw 2008). While the "business-related" projects are undertaken to improve existing technologies and to develop new core-business-related technologies, the "business-unrelated" R&D projects serve to explore and develop technologies that do not fit the firms' business field in the first place. The "business-unrelated" projects are needed to adopt a broader view on technological developments in the sense of outbound open innovation management in order to find potential new internal applications or opportunities for radical innovation (Stüer et al. 2010). Although these "business-unrelated" R&D projects help firms to cover a broader spectrum of technological developments, their technological outcome with additional value for the core business or an internal commercialization opportunity is difficult to foresee beforehand.

As illustrated in Fig. 3, the outcome of R&D projects in the form of usable technologies (strategic fit with the existing or probability of fit with the future product portfolio or the firm's strategy) should be only commercialized externally when external commercialization provides a further strategic advantage, e.g., to foster an industry standard. Otherwise, these technologies should not be externally commercialized because they are the fundament for a firm's competitiveness in the future. The developed (finished or not) non-usable technologies that probably do not match the firm's product portfolio or strategy should only be sold or licensed externally when the transaction revenues significantly surpass the transaction expenses, as illustrated in Fig. 3. Here, we could, however raise the question of why these R&D projects have not even been stopped or re-scoped earlier, assuming that ETC is not part of the corporate or R&D strategy. In these cases, we would conclude

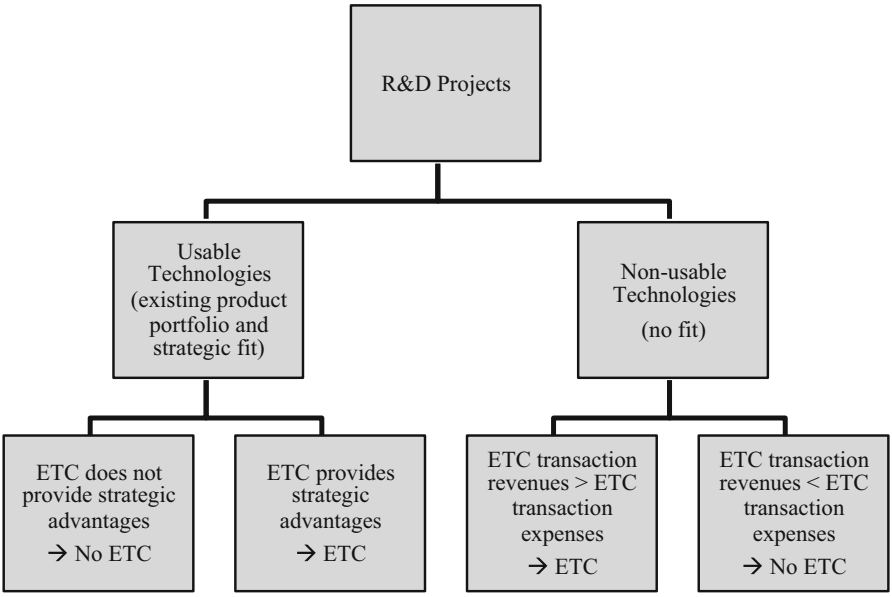

Fig. 3 Decision tree—When to use ETC

that ETC is only a spare wheel in emergencies and not a normative approach. Regular potential analysis (profit and loss potential) of R&D projects including an ETC opportunity and threat evaluation could thereby help to optimize R&D resource allocation.

7 The case of ETC in the German automotive industry

We illustrate and further explore our propositions by discussing and analyzing the ETC practice with practitioners in the automotive industry in Germany by means of a single case study. Typically, case studies take place within a real-life context, combine numerous data collection methods and sources and tend to focus on an in-depth understanding of the dynamics in a single setting (Yin 2009; Eisenhardt and Graebner 2007). Furthermore, illustrative case studies provide an empirical exemplar of the embodiment of particular theory, method or categorizations and show how it could be used in practice (Scapens 2004). The case study was conducted in 2017 and is based on data from a leading German automotive manufacturing company that is listed in the DAX index of 30 selected German blue chip stocks. Open innovation became part of the formal innovation strategy of the firm approx. since 2010. We gathered secondary data that was publicly available at firm websites or other media and primary data in form of expert interviews (Gläser and Laudel 2010). Moreover, we identified three key informants: A senior innovation manager and inventor who holds or is involved in over a hundred patents himself and the other holds a dedicated "Open Innovation Manager" position in the central R&D organization of one division. The third was an innovation management consultant for this company who was active in projects that were in the context of open innovation and business model development. During our conversations (in person, on the phone and via Internet), we also presented our propositions developed in this paper and discussed them with our informants. Their views and evaluations were integrated by means of expert triangulation and by pattern matching to establish a chain of evidence until a common view was reached and by that high internal validity was ensured (Yin 2009). The key findings of our case analysis are outlined here:

Outbound open innovation as a promising opportunity for the innovation strategy of one division of the case firm was identified and initiated by the senior innovation manager and the innovation consultant in 2010. However, after initial enthusiasm it turned out to be difficult to implement. It turned out that ETC was not uniformly suited for any industry or firm to the same degree. The challenges in this case might be also instructive to illustrate why ETC might be less suitable or challenging:

- *Limited but existing potential for ETC in the organization*

Since the innovation strategy traditionally focused on incremental, exploitative innovation and a quite restrictive and rigorous R&D-project selection process was used, few technology development unrelated to the core business fields was produced in the years before the official open innovation strategy was implemented.

However, in the later stages of the innovation process, also alleged related and customer-oriented R&D-projects can turn out to be rejected by the operative business units or customers. Since complex products and technology systems dominate in the automotive industry and the tendency to avoid monopolistic supplier power by the Original Equipment Manufacturer (OEMs) also leads to a technology development where few generic key patents are available for attractive license opportunities. In particular, the firm held usually a fast follower technology position that limited the potential for sufficient high quality IP for ETC and the reasonable investment in related ETC capacities. However, also in focused technology development processes finally "unrelated" technologies can provide a (limited) potential for ETC. *Therefore, we propose that industry factors, business model, innovation strategy and process influence how suitable ETC fits to an organization.*

- *Additional transaction, change and coordination costs caused by ETC*

In order to enable an effective ETC-capability, innovation and patent management departments and processes needed to be better aligned which produced additional transaction and coordination costs. Since primarily, the innovation process was not enabled to cope with un-realized R&D-projects in terms of ETC. *Therefore, we propose that to enable an effective ETC-capability additional transaction, change and coordination costs can occur for the organization.*

- *ETC can produce strategic and cultural conflict between ETC and the core business*

Traditionally the firm pursued a defensive patent and restrictive license strategy. The license strategy in the industry was handled restrictive between competitors in the supplier segment due to the negative cost effects for their common customers (OEMs). Therefore, the need to actively manage and exploit the existing IP-portfolio was seen as nonessential, unusual and thus few dedicated resources were established. Additionally, the innovation strategy and culture was focused on defending existing competitive advantages and businesses. Such strategic stance was seen as a typical pattern in the automotive industry. The traditional strategic and cultural stance was perceived as a roadblock for effective outbound open innovation activities including ETC due to unwillingness to disengage even from unused or unrelated technologies. Therefore, it was perceived as challenging to shape an open mindset, away from the focus on the automotive industry and its typical way of thinking. This type of problem could also be interpreted as NSH (Not-Sold-Here Syndrom). Also joint ventures activities frequently had problems of strategic conflict with their incumbent firms due to their very mission of successfully expand their business and enter new markets. Typically, activities that were perceived as less important for the foundation of competitive advantage were transferred in joint ventures to share the R&D costs. In a similar vein, spin offs can also produce a loss of technological competencies, strategic control of technologies, self-cannibalization for the incumbent firm and reduce the cost effectiveness in the overall firm structure due to new emerging profit margins of the spin offs. *Therefore, we propose*

that to enable an effective ETC-capability, strategic and cultural barriers might need to be overcome in the organization or inhibit effective ETC activities.

- *Lack of appropriate competences and resources for ETC induce opportunity costs and new fixed costs*

Since no employees or departments with specific expertise for ETC were available, a dedicated "Open Innovation Manager" position was created in order to exploit the existing potential for ETC. Since the massive size (thousands of patents) and complexity (specific and deep technological knowledge requirements) of the existing IP portfolio lead to problems to identify appropriate technologies or patents for ETC, analyzing larger fractions of the existing IP portfolio turned out to be time, cost and very knowledge intensive. Employees with this specific expertise are a rare asset and could also be used for alternative purposes in the core business. Alternatively, an active role of the inventors would be possible to realize the hidden potential of the patents. However, motivations and the related incentive structure of the organization are seen as critical for taking this active role. Moreover, the incentive structure is driven by strategic and cultural conditions that might be in conflict with ETC and the traditional core business. Finally, opportunity costs for resource allocation and profits outside the established business model such as ETC were perceived as high due to high degree of capacity utilization in R&D, uncertainties of ETC revenues and lacking deabsorptive capabilities. At the same time, there was a lack of incentives in the automotive industry for standard setting on the level of the OEM suppliers due to the industry structure that limits the opportunities for ETC. Only few examples of successful standard setting by an OEM supplier existed in the German automotive industry to this date. *Therefore, we propose that a lack of appropriate competences and resources for ETC can induce high opportunity costs and new fixed costs for the organization.*

- *Lack of technology maturity for ETC via online platforms and broker*

The needed maturity levels of the internal developed technologies to successfully transfer or sell them via online platforms typically need high investments and further technology development. Those activities again need special and rare resources such as entrepreneurial employees and R&D resources to refine the unused technologies. *Therefore, we propose that a lack of maturity of the unused technologies might inhibit the effective use of online platforms and broker for ETC.*

- *However, we also identified and illustrated why ETC might be more suitable for a firm to pursue*

Our case firm recently started the incubation of spin offs as a reaction to recent technology dynamics in the industry structure that challenge the clock speed due to restrictions of existing structures and business models in the automotive industry. These recent dynamics also induced a greater need for explorative R&D projects due to higher uncertainties. Therefore, more unrelated R&D projects with less clear

business implications were started with a different innovation approach that intents to produce also less "waste" technologies.

8 Discussion, conclusion and future research

On the one hand, ETC is still justified in that it offers opportunities that are suitable to address imperatives in global competition. On the other hand, we showed that ETC involves many challenges and threats for a firm that does not focus on ETC. In Table 1, we confronted the main advantages and disadvantages of ETC.

Although the aim of this article was to provide a critical view on ETC, it should not be misunderstood as a complete dismissive attitude towards ETC. By discussing the advantages and disadvantages of ETC we wanted to broaden managers' perspective on ETC. The main point we wanted to make is that ETC is not always—in every situation or context—a firm's success factor. In line with our arguments and the illustrations from the case above, we can conclude that "the more openness, the better" is not true because of the costs and risks related with ETC. It is a positively biased presentation to assume ETC is always the optimal solution for current challenges in innovation management because this depends on a firm's strategic, organizational and managerial context and on an acceptable trade-off between the benefits and costs. In addition, our case study suggests that the maturity level of internally unused technologies might play a relevant role if ETC should be practiced.

Table 1 Pro and contra ETC

Advantages and opportunities	Disadvantages and threats
Positive effects on operating result due to higher volume of sales and profits	High to very high need of resources (Opportunity & transaction costs)
Greater financial scope of action	Employees with specific and partly new expertise, e.g. "Open Innovation or ETC Manager"
Amortization of R&D-costs	Time
	Money
Promoter for sales quantity of a firm	Resource, cultural/mindset (NSH) and strategy conflict and confusion between ETC and core business
	Need for change management in the innovation/IP process, strategy/business model and culture
Establishment of own technologies as industry standard	Abandonment of competitive advantages, weakening of own competitive position in core business field
Reduced sunk costs	Absence or lack of control over distribution and use of released knowledge
Higher pace of innovation	Fostering non-core business innovations of other market players
	Opportunistic behavior of partner or acquirer
	New fixed costs by strengthening ETC capabilities
	Increased complexity and coordination

We further need to point out that a too excessive execution of ETC or the poor execution of ETC can be counterproductive for a firm's performance. This finding must be taken into account for future decisions and for strategic planning of the innovation management to prevent the illustrated problems and challenges.

The potential loss of core business focus and the loss of competitive advantages can be prevented or minimized by a well-defined R&D and technology strategy incorporated in the firm's overall strategy and a systematic, well-structured R&D portfolio management approach (Cooper and Edgett 2010; Wheelwright and Clark 1994; Dowling and Hüsig 2002). This includes a careful evaluation of and selection process for technology projects to know which projects to follow up internally and which to commercialize externally—when suitable and useful. Managers are thereby able to control the portfolio's performance according to the defined R&D strategy, budget, resources, and linkages across the R&D projects. In addition, to prevent a potential competitive loss, a firm should invest a certain percentage of the R&D budget in "business-unrelated" R&D projects to explore and develop technologies that could become relevant for future competition (Stüer et al. 2010). Our case study illustrates, that this might be necessary especially in dynamic technology conditions.

Though this article does not only address the managers responsible for ETC in corporations, it shall invite researchers of any particular subject area to close the existing gaps. The new critical view on this concept requires further research. First, we recommend to identify and analyze more case studies in order to be able to cover and describe in detail the whole impact of ETC on a firm. Moreover, long-term studies are further necessary to test the complex construct and long-term effects of ETC such as the loss of competitive advantages. Only well-grounded and specific research findings that cover the whole picture of ETC including its negative consequences can help corporations in making the right decisions concerning their strategy, innovation management, and R&D management to be able to address the challenges of todays fast changing environment by avoiding "one size fits all" management recommendations.

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