

POST-PRINT VERSION

Paavo Ritala, Kenneth Husted, Heidi Olander, Snejina Michailova

2018

**External knowledge sharing and radical innovation:
the downsides of uncontrolled openness**

***Journal of Knowledge Management*, Vol. 22 Issue: 5, pp. 1104-1123**

<https://doi.org/10.1108/JKM-05-2017-0172>

EXTERNAL KNOWLEDGE SHARING AND RADICAL INNOVATION: THE DOWNSIDES OF UNCONTROLLED OPENNESS

Abstract

Purpose – Inter-firm collaborative innovation typically requires knowledge sharing among individuals employed by the collaborating firms. However, it is also associated with considerable risks, especially if the knowledge-sharing process is not handled using proper judgment. Such risks have been acknowledged in the literature, but the underlying empirical evidence remains unclear. In this study we examine how sharing of business-critical knowledge with external collaboration partners affects firm's innovation performance.

Design/methodology/approach – We develop a mediating model and hypotheses predicting that the uncontrolled sharing of knowledge leads to accidental knowledge leakage, which, in turn, hinders in particular firm's radical innovation performance. We test the model using a survey of 150 technology-intensive firms in Finland and a partial least squares structural equation model. The mediating model is tested with incremental and radical innovation performance, and we control for firm size, age, R&D intensity, as well as industry.

Findings – We find strong support for our model in that uncontrolled external knowledge sharing leads to accidental knowledge leaking, and to lower radical innovation performance. The same results are not found for incremental innovation, implying that uncontrolled knowledge leakage is especially detrimental to radical innovation.

Originality/value – These findings help us better understand some of the downsides of too much openness and lack of judgment about knowledge sharing beyond the boundaries of the firm. Thus, firms pursuing radical innovation should carefully guide their employees in regard to what knowledge they share, to what extent they share it, and with whom they share it.

Keywords: Inter-firm collaboration, Knowledge sharing, Knowledge leakage, Radical innovation, Incremental innovation

1. Introduction

Firms share knowledge with external partners for various important reasons and with several strategic purposes in mind. Sharing knowledge externally helps firms scan the competitive landscape in which they operate, develop new ideas and capabilities, and eventually pursue incremental and/or radical innovations (Alexy *et al.*, 2013; Foss *et al.*, 2010). Since knowledge exchange between partners tends to be reciprocal, external knowledge sharing helps to bring about benefits for innovation within and beyond the partnership context (Tranekjer and Knudsen, 2012; see also Serenko and Bontis, 2016). Indeed, research has shown that sharing knowledge externally can be beneficial for firms' innovation performance (Lazzarotti *et al.*, 2011; Lin, 2007; Ritala *et al.*, 2015), and is a necessary condition for open innovation (Chesbrough, 2006).

However, sharing external knowledge also involves risks. Since valuable core knowledge plays a critical role in creating and sustaining the firm's competitive advantage, this knowledge needs to be protected (Hernandez *et al.*, 2015; Katila *et al.*, 2008). Indeed, sharing and exposing too much of such valuable core knowledge can have negative effects on the firm's innovation performance (Baughn *et al.*, 1997; Dahlander and Gann, 2010; Hannah, 2005), the firm's overall performance (Frishammar *et al.*, 2015), and the firm's competitive advantage in the future (Norman, 2002). Hence, firms are conscious of the need to deter knowledge spillovers and imitation (Ethiraj *et al.*, 2008) and are careful in determining "what type of knowledge is valuable" and "how this knowledge is shared" (Connell *et al.*, 2013, p. 140). At the same time, it has been found that revealing some amounts of knowledge (deliberately or accidentally) to partners can be beneficial (Alexy *et al.*, 2013; Alnuaimi and George, 2016; Henkel, 2006). Leaks may turn out to be advantageous if they, for example, help spreading information that leads to new business opportunities and enhances the buzz around a product or technology (e.g., Alexy *et al.*, 2013). Outgoing spillovers also enable the formation of a recombined pool of complementary knowledge and capabilities between partners (Yang *et al.*, 2010), which feeds important knowledge back to the originator that can enhance innovative efforts and performance.

Considering the potential benefits and risks, the role of core knowledge in collaborative innovation presents a daunting paradox for managers of firms that engage in such collaborative relationships. As pointed out by An *et al.* (2014), collaborative innovation is very much dependent on both sharing and protection of knowledge in organizations. Achieving a balance between sharing and withholding core knowledge is vital (Stenius *et al.*, 2016), since incentives to innovate

have been noted to stem from a firm's ability to protect the value of its knowledge assets and the degree to which it appropriates future rent streams (Liebeskind, 1996). In particular, knowledge that relates to radical innovations loses its value if it is exposed too widely (Li *et al.*, 2008). At the same time, striking a balance between not disclosing and sharing knowledge is difficult – firms often find themselves being either over-protective by sharing too little knowledge with partners, or under-protective by sharing too much knowledge and risking the leakage of core knowledge to others (Frishammar *et al.*, 2015; Husted and Michailova, 2010; Norman, 2002). This leads to tension between the benefits and risks of sharing knowledge externally in the pursuit of innovation (Heiman and Nickerson, 2004). Conceptualized as the “paradox of openness,” Laursen and Salter (2014: 870) state that “openness and some sort of appropriability strategy go hand in hand: firms need to disclose some knowledge in order to gain from external partners, but they need to also protect parts of their knowledge if they are to gain value from the exchange.” Arora *et al.* (2016: 1352) referred to this as a tension between “organizational openness” and “spillover prevention.”

How does then one solve the “paradox of openness” regarding core, business-critical knowledge in collaborative innovation? Li *et al.* (2008) argue that firms should focus on carefully identifying what knowledge to share and with whom, especially when there are risks of core knowledge leakage. Further, Henkel (2006) and Alexy *et al.* (2013) advocate for selectively revealing some parts of the firm's knowledge base. We argue that a key to understanding some of the downsides – and how to avoid them – is in the openness of the process of individual-level knowledge sharing with external partners. Some valuable, business-critical knowledge will be shared eventually, and when this happens, the process should involve careful judgment about who should receive this knowledge in the partner firm. The most delicate situations arise when the focal firm possesses knowledge that has the potential to provide a radical departure from the current knowledge, and when this knowledge unintentionally spills over, it might lose its value (Li *et al.*, 2008).

In our attempt to explain this issue, we address an important research gap. As discussed so far, a cumulating body of research supports the idea of the perils of uncontrolled openness in external knowledge sharing; however, the empirical evidence on the issue is relatively limited. This lack of empirical research on the topic is quite surprising, given the relevance of the issue for inter-firm collaboration, knowledge sharing and innovation. Therefore, inquiring into this phenomenon is relevant in both scholarly and practical terms. Furthermore, since knowledge

sharing is a personal-level phenomenon (van Dijk *et al.*, 2016), there are increasing calls for further research that focuses more on the individuals who share (and receive) knowledge, rather than on aggregating this behavior to organizations (e.g., Foss *et al.*, 2010; Ghosn and Rosenkopf, 2015; Salter *et al.*, 2015). The current literature also reveals a noticeable gap in the understanding of the knowledge-sharing activities of “provider side firms” in collaborative and open innovation (Tranekjer and Knudsen, 2012). Finally, while the effects of radical innovation have been studied extensively, less attention has been paid on the origins of such innovation (Delgado-Verde *et al.*, 2011; Schoenmakers and Duysters, 2010). Such an imbalance between studying the outcomes of at the cost of antecedents to is unwarranted.

To address these issues, we pose the following research question: *How does a firm’s sharing of business-critical knowledge with external partners affect its radical innovation performance?* Employees in the collaborating firms could unintentionally spread partnership-specific knowledge too widely if there is no system for handling the received knowledge. The question is, therefore, not so much whether employees share core knowledge with their external partners but whether they know how to distinguish between desired and undesired knowledge sharing and can make appropriate decisions regarding what to share and with whom. To answer this question, we develop hypotheses suggesting a mediating model where uncontrolled (vs. selective) openness in sharing knowledge externally leads to accidental knowledge leakage, which, in turn, hinders a firm’s radical innovation performance. We test the hypotheses with partial least squares structural equation model, utilizing data from a survey of 150 technology-intensive firms in Finland. Our results show that uncontrolled external knowledge sharing leads to accidental knowledge leaking, and to lower radical innovation performance. We do not find the same results for incremental innovation, implying that uncontrolled knowledge leakage is especially detrimental to radical innovation.

These results provide novel insights into the dynamics of inter-firm knowledge sharing and leaking, and resulting focal firm innovation performance, and thus contribute to scholarly debates in the knowledge management and innovation space. First, our study contributes to the literature on innovation appropriability in the collaborative innovation context. Specifically, our analysis examines the boundaries of the benefits of openness, in showing that openness in knowledge sharing might have different types of outcomes, depending on the type of innovation (i.e. incremental vs. radical). Second, our results contribute to the growing literature on inter-

organizational knowledge sharing by examining the relationship between knowledge sharing and knowledge leakage. While the issue of knowledge sharing has been discussed extensively in the literature (for a review, see Foss *et al.*, 2010), the relationship between sharing and leaking is much less clear. Third, bearing in mind that most prior studies on this topic are conducted at network/alliance level (Dyer and Nobeoka, 2000; Kale *et al.*, 2000; Norman, 2002) or firm level (Hoetker and Agarwal, 2007; Laursen and Salter, 2014), we adopt a more fine-grained approach and conduct our investigation at the individual level – an issue to which we return in the presentation of our methodology. In doing so, we respond to recent calls for gaining more knowledge of how individual choices about appropriability and knowledge-sharing openness shape a firm’s performance (Frishammar *et al.*, 2015; Hannah and Robertson, 2015; Ritala *et al.*, 2015).

2. Background and hypotheses

2.1. Appropriability of radical innovation, knowledge sharing, and knowledge leakage

Appropriating value from innovation is the key motivation behind an innovation activity. As innovations are valuable combinations of knowledge, the ownership and control rights to such knowledge determine how much the innovating firms are able to benefit from such knowledge (Teece, 1986). Radical innovations are combinations of knowledge that are particularly novel and disconnected from current technologies, processes, and practices (Abernathy and Clark, 1985). It is much more difficult and rare to come across radical innovations than incremental innovations, but the former nevertheless have a stronger effect on a firm’s long-term success as well as on the development of markets and industries (Brown, 2010). Therefore, radical innovation is both high-risk and high-return, and innovation appropriability is a critical condition in this context.

To understand the appropriability of radical innovation, focusing on the role of knowledge and its sharing across organizational borders is fundamental. We highlight that external relationships have been found to have highest impact on radical innovation (Delgado-Verde *et al.*, 2011). Also, radicalness is *per se* a departure from existing knowledge (Abernathy and Clark, 1985) and thus the new knowledge embedded in the radical innovation should be disconnected from the existing knowledge space. If such a disconnection does not occur, the value of the novelty embedded in the innovation will be rather incremental in nature. Thus, the potential for radical innovation can be perceived as a function of securing the core parts of the radical knowledge

combinations within the boundaries of a focal innovator, at least to the point where the innovation can be commercialized. The further and the more firm-specific core knowledge is dispersed, the more it diminishes the value embedded in the “radicalness” of the innovation. Indeed, such knowledge loses its value if it is exposed too widely (Li *et al.*, 2008).

In a collaborative innovation context, the problem of innovation appropriability is especially challenging, as recent studies have highlighted (Laursen and Salter, 2014; Ritala and Hurmelinna-Laukkanen, 2013). Despite the apparent risks, research has shown that collaborative innovation is useful – if not crucial – for radical innovation (Belderbos *et al.*, 2004). In fact, radical innovations are often a result of collaborating with external partners (West and Bogers, 2014). Reciprocal knowledge flows among different actors in the collaborative innovation allow the knowledge combinations needed for radicalness to be achieved. Knowledge sharing in radical innovation has two contrasting effects on the potential radical innovation performance of the focal firm. On the one hand, the more knowledge is shared among collaborating actors, the more potentially valuable radical combinations may emerge, which can be appropriated eventually by the focal firm. On the other hand, the value of novelty embedded in radical knowledge combinations diminishes when more knowledge is dispersed in the immediate inter-organizational network of the firm and beyond it, including to the firm’s competitors. We argue that two factors are especially relevant to explain these problems in context: (1) the individual-level judgment regarding the scope of external knowledge sharing and (2) the business-critical, core knowledge leaked outside organizational boundaries.

2.2. Hypothesized model and level of analysis

Building on the underpinnings outlined above, our two starting points are that (1) pursuing radical innovations is a risky and uncertain endeavor (Keizer and Halman, 2007; O’Connor and Rice, 2013), especially when the innovation efforts involve external partners (Mata and Woerter, 2013), and (2) the knowledge related to such innovations loses its value if it is spread too widely (Li *et al.*, 2008).

We focus on the individual level of analysis to consider whether knowledge is shared or leaked, since individual employees are the actual agents making the decisions regarding what and with whom to share both in general (see Van Dijk *et al.*, 2016), as well as in collaborative innovation contexts (Bogers, 2011; Husted and Michailova, 2010). We note that while there are

investigations conducted at the network and firm levels, individual-level examinations are lacking, and it is only recently that the focus has shifted to individuals (e.g. Salter *et al.*, 2015; Järvenpää and Mächrzak, 2016). Thus, our analysis is concerned with individual employees who participate in collaborations on behalf of their firm. Organizations can benefit from allowing their employees to selectively share (non-core) knowledge beyond the firm's boundaries due to the reciprocity of communication (see e.g. Alexy *et al.*, 2013, 2017). While generally beneficial, such reciprocity implies that firms are vulnerable to their employees' continuous exercise of judgment over knowledge sharing.

From this baseline rationale, we propose a hypothesized model that we depict in Figure 1. The model suggests that the uncontrolled (as opposed to controlled, selective, and judicious) external sharing of business-critical knowledge will be negatively associated with a focal firm's radical innovation performance and that this relationship will be mediated by accidental knowledge leakage.

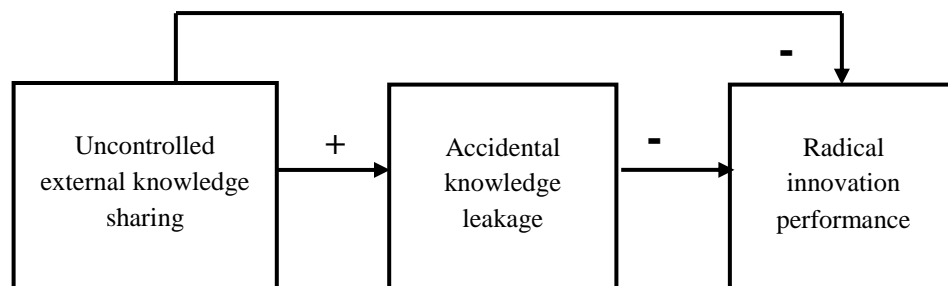


Figure 1 Hypothesized conceptual model

The dependent variable, *radical innovation*, is defined as completely new products or services (e.g., Abernathy and Clarke, 1985; Tushman and Anderson, 1986). This contrasts with *incremental innovation*, which refers to products or services that are mere improvements on existing ones (Abernathy and Clarke, 1985; Tushman and Anderson, 1986). We particularly argue this model to hold for radical innovation, because we expect it to be affected especially by the loss of novelty value. Furthermore, in our empirical inquiry, we are interested in *radical innovation performance*, i.e. how much the firm's sales originate from products and services in this category, as opposed to incrementally improved products or services, or those that have remained unchanged.

Uncontrolled external knowledge sharing refers to the lack of individual-level judgment about business-critical knowledge sharing with an external partner. This judgment is perceived as the employee's decision concerning whether to share knowledge with anyone in the partner organization(s) or only with the appropriate persons. When the employee does not carefully consider with whom to share business-critical knowledge, the sharing is 'uncontrolled'. In our model, this is suggested to lead to *accidental knowledge leakage*. This concept refers to situations where a firm's employee accidentally exposes business-critical knowledge that is not meant to be shared with external parties (Ritala *et al.*, 2015). These unwanted knowledge spillovers, also called leakages of knowledge to non-authorized people (Ahmad *et al.*, 2014), are a central issue in knowledge protection research (Manhart and Thalmann, 2015). Examples of knowledge sharing that leads to unwanted leakage include unrestrained collaborative environments, permitting overly easy access, and excessively open and exhaustive sharing with a partner about designs, products, and processes (Jiang *et al.*, 2013). The leakage could take place through frequent communication and interactions between individual members of the collaborating firms (Kale *et al.*, 2000) or at professional fairs, exhibitions, code committees, or other formal or informal occasions. It could also happen due to an individual's enthusiasm when he/she perceives the partner as trustworthy or otherwise identifies with the partner (e.g. Husted *et al.*, 2013). All in all, we argue that such leakages will lead to the loss of radical innovation performance of the focal firm.

In the following subsections, we provide key theoretical arguments that lead us to develop the two formal hypotheses that link the key constructs explicated in the model.

2.3. External knowledge-sharing openness and radical innovation performance

We start our theorizing with the direct link between knowledge sharing openness and innovation performance (the upper arrow in Figure 1). In contrast to incremental innovation, radical innovation often occurs in the context of small teams of individuals and organizations (Stringer, 2000). In such settings, extensive knowledge sharing with external parties is not necessarily an optimal option, as the benefits may be outweighed by the risks of limited value capture and even the loss of one's core knowledge (Olander *et al.*, 2011). Radical ideas enable the best capture of value when they are only shared with a closed group; radicalness tends to "escape" when the ideas are shared too openly and/or too widely (Li *et al.*, 2008).

Based on the novelty value embedded in radical innovations, we suggest that uncontrolled openness may be harmful when contrasted with the controlled or selective sharing of business-critical knowledge. Alexy *et al.* (2013, 2017) argue that it is highly beneficial for a firm to put forward some core knowledge while still retaining its essential insights internally. As mentioned earlier, in a partnership context, selective sharing requires the individual employee's judgment regarding what exactly should be shared and with whom. For example, partner firms often use collaboration contracts that include confidentiality clauses, or employees involved in knowledge exchange may be required to sign nondisclosure agreements about the collaboration in question. These measures provide at least some formal protection for a firm's knowledge, as they are considered reminders to the employees about their responsibility of safeguarding trade secrets and core knowledge (Hannah, 2005). However, such measures might not always regulate the actual behavior in knowledge sharing, as much of the process takes place at the individual level and is dependent on the employee's choices, judgment, care, and overall understanding of the content of the knowledge. If knowledge relating to radical innovation is shared without judicious consideration, the knowledge may leak beyond the partner organization(s) and even reach the focal firm's competitors (Laursen and Salter, 2014), reducing the radicalness of the innovation.

2.4. External knowledge-sharing openness and accidental knowledge leakage

The literature suggests that knowledge is typically shared most effectively among employees who have the same or similar backgrounds (Wenger and Snyder, 2000). Provided that these employees are selected to collaborate on a specific project or partnership interface, they will likely share some similar features. Moreover, they are assigned to work toward achieving a common goal – namely, that of the collaboration project. In this sense, they work in the context of a public good dilemma. In other words, they (and their organizations) all benefit, irrespective of the extent to which they individually contribute (van Dijk and Wilke, 2000). However, when core knowledge is shared, the collective interest leading to intensive knowledge sharing between partners might still coincide with the private benefits of the focal firm.

Husted and Michailova (2010) emphasize that while the failure to share knowledge sufficiently can result in a firm's inability to realize the intended benefit from the collaboration, excessive knowledge sharing can lead to a loss of firm-specific knowledge and thus limited chances for enhancing the firm's competitiveness in the future via core knowledge-based

innovations. Specifically, the employees labeled by these authors as “gone natives” (those who are more allegiant to the collaboration than to their own firm) are likely to engage in too much knowledge sharing with the partners (see also Husted *et al.*, 2013). The established connectedness, openness, and trust based on social relations among individuals tend to foster such behavior (Jansen *et al.*, 2006; McFadyen and Cannella, 2004; Subramaniam and Youndt, 2005). Such uncontrolled openness toward external partners is likely to lead to accidental knowledge leakage. This occurs at an interpersonal level among the individuals collaborating on behalf of the partnering firms that employ them. Knowledge sharing may happen in mundane day-to-day, more formal work-related activities as well as in more informal social contexts.

2.5. Mediating effect of accidental knowledge leakage

Thus far, we have argued that since radical innovation activities are risky and uncertain (Mata and Woerter, 2013), and their novelty vanishes if knowledge about them is prematurely disseminated (Li *et al.*, 2008; Oxley and Sampson, 2004), the choices that a firm’s employees make in terms of external knowledge sharing are critical to the success of such innovation activities. Therefore, we expect the employees’ uncontrolled, rather than selective, knowledge sharing with external partners to be harmful to radical innovation performance. We also propose that such knowledge sharing increases the likelihood of accidental knowledge leakage. These combined arguments suggest the existence of a mediating effect: accidental knowledge leakage will negatively mediate the relationship between uncontrolled external knowledge-sharing openness and radical innovation performance.

This mediating process takes place when knowledge is shared carelessly by the focal firm’s employees, and in this process, some key aspects of radical innovation may spill over, not only to the partner firm but even further away in the network, including rivals (Frishammar *et al.*, 2015; Hernandez *et al.*, 2015; Pahnke *et al.*, 2015). First, this can strip away some of the novelty of the focal firm’s innovation (Ponce, 2011; Scotchmer and Green, 1990), and relatedly, it may cause the firm to lose its lead time and commercialization potential if imitators are able to enter the market first (Cohen *et al.*, 2002). Such processes lead to the reduction in radical innovation performance of the focal firm. Overall, the conceptual model and the arguments provided so far allow us to put forward our main mediating hypothesis:

Hypothesis 1: *Accidental knowledge leakage will negatively mediate the relationship between uncontrolled external knowledge sharing and radical innovation performance.*

To further study the potential harmful effects of uncontrolled knowledge sharing on radical innovation performance, we also develop a comparative hypothesis related to incremental innovation. In particular, it is important to know whether our arguments on the novelty of radical innovation and related risks of knowledge sharing and leakage also hold for innovation that is less novel. While radical innovation refers to completely new products or services, *incremental innovations* are products or services that gradually improve existing ones (Abernathy and Clarke, 1985; Tushman and Anderson, 1986). Therefore, based on our arguments so far, we expect incremental innovation performance not to be affected to the same extent as radical innovation from unwanted knowledge leakage in inter-firm collaborations. While radical innovation related knowledge might seriously lose its value when accidentally leaked outside, diffusing knowledge of incremental developments leads to less harmful exposure given that such knowledge is more familiar to all industry peers and there is thus less novelty value. Therefore, we hypothesize the following:

Hypothesis 2: *Accidental knowledge leakage does not have a negative mediating effect on the relationship between uncontrolled external knowledge sharing and incremental innovation performance.*

3. Data and methods

3.1. Sample and data collection

To test the hypotheses, we use survey data collected in 2012 from members of the Federation of Finnish Technology Industries. This national industry association covers Finland's most important industry sectors in terms of R&D investment (80% of the total national investment) and 55% of Finnish exports (Federation of Finnish Technology Industries, 2014). Therefore, this empirical context is ideally suited for testing our hypotheses regarding knowledge sharing, leakage, and radical innovation performance. The survey was pretested with a panel of experienced industry practitioners, allowing us to improve the clarity of several of the survey items prior to launching the survey. We subsequently surveyed firms with at least 10 employees, and the overall

population of comprised 1,273 companies in the machinery and metal, electronics, information technology, and planning and consulting industries.

In selecting the respondents, we followed the key informant selection criteria specified by Kumar *et al.* (1993). For examining phenomena such as those in which we were interested, we expected each key informant to possess a wide range of knowledge about his/her firm's activities and events, employees' behaviors, and the firm's innovation performance. Thus, we surveyed the chief executive officer (CEO) of each firm in the sample. The mean number of employees per company was 148, and the median 44, and therefore we expect the CEO to be rather well-informed about the activities in firms of these sizes. Attached to the survey was a cover letter explaining that the respondent should answer to the best of his/her judgment on behalf of the whole organization. We received 150 responses, representing an effective response rate of 11.8%. In our view this is considered reasonable, especially given the high status of the informants (see also Bartholomew and Smith, 2006). Furthermore, we believe that this unique set of high-profile informants provides a feasible dataset that allows us to assess knowledge sharing and leakage behavior in inter-firm context, as well as firm-specific innovation performance. Also, as our sample represents multiple industries, and the studied phenomena are rather universal, we believe that our results can provide implications to various types of firms and industry contexts.

Nonresponse bias was tested by comparing two groups of informants – those who answered after the first contact and those who answered after the reminder. We used an independent samples T-test to assess the mean differences between the two groups in all the independent and dependent variables as well as the demographic variables. We did not find statistically significant differences for any of these variables. Table 1 describes the key characteristics of the sample.

Table 1 Sample characteristics

<i>Industry</i>	<i>N</i>	<i>Mean age (years)</i>	<i>Mean sales (MEur)</i>
Manufacturing and mechanical engineering	84	21.15	32.21
Electronics and electro-technical	21	16.38	131.15
Information technology	19	16.74	17.73
Consulting engineering industries	26	15.38	19.40
Total sample	150	18.93	42.06

3.2. Measures

The dependent variable, *radical innovation performance*, was measured as the estimation of a radical innovation's effect on the total turnover of the focal firm in 2011. The survey respondents were asked to estimate how the total turnover in 2011 was distributed among three categories: (1) products/services introduced in 2009–2011 that were completely new (radical innovations), (2) products/services introduced in 2009–2011 that were improved (incremental innovations), and (3) products/services that have practically been unchanged in the last three years. This categorization allowed us to assess how knowledge sharing and leakage would affect not only radical innovation performance but also *incremental innovation performance*, which we used as a dependent variable for robustness checks to assess whether our model would also work in the domain of incremental innovations. Measuring innovation performance with these types of measures enabled an unambiguous assessment of innovation outcomes (as opposed to multi-item variables, for instance). Considering the typically challenging nature of measuring innovation outcomes, we followed Belderbos *et al.* (2004) and Tomlinson (2010) in choosing single-item measures for incremental and radical innovations.

We estimated *uncontrolled external knowledge sharing* with a measure developed on the basis of Fugate *et al.* (2009) work on the scope of knowledge sharing. We asked the respondents to assess the typical behavior of the focal firm's employees when they became aware of business-critical knowledge, in the context of a specific partnership. First, the respondents were provided with a definition of "business-critical knowledge" as "the type of knowledge that significantly affects the possibilities of the company to operate competitively in its markets." The logic behind this measure was that when business-critical knowledge was available and related to a specific partnership context (e.g., technology, market knowledge, and product ideas), this knowledge would become relevant and valuable when shared across organizational boundaries. However, since the potential of knowledge leakage is affected by how widely in different contexts the knowledge is shared (e.g. Hoecht and Trott, 2006), the developed measure focused on important differences in the scope of the employees' knowledge-sharing behavior. One alternative was to share knowledge very openly, without using judgment regarding the role and status of the knowledge recipients in the partner organization(s). Another alternative was to be more focused and selective, sharing such knowledge only with the appropriate persons within the partner organization(s). The developed measure was intended to capture this logic by presenting three

potential knowledge recipients: the partner's contact personnel, the partner's other functional departments/teams, and the partner's senior management (see Appendix A for details).

Accidental knowledge leakage was estimated with a two-item composite measure (see Appendix A) developed by Ritala *et al.* (2015). The two items focused on scenarios where business-critical knowledge would be leaked accidentally: (1) leakages to external partners and (2) leakages in other situations. The first item referred to the typical situation in the collaboration interface, where it could be pinpointed that the knowledge was leaked to external partners. The second item covered a range of other situations where business-critical knowledge might be leaked, such as professional fairs or exhibitions. As such situations could take many different forms, we expected that this measurement, together with the first item, would provide enough simplicity to capture the core of the phenomenon (as suggested by Ritala *et al.*, 2015).

Control variables were also included to ensure that the explanations for the dependent variable, as well as the demographic differences among the sampled firms, would be controlled for. Industry dummies were included in all models, categorized on the basis of the industry categories used by the Federation of Finnish Technology Industries. These comprised the manufacturing and mechanical engineering (used as a benchmark dummy), electronics and electro-technical, information technology, and consulting engineering industries. The size, age, and R&D intensity of the firms were also controlled for, as these factors could affect the innovation output and the focal firm's resources for innovation in several ways (Chandy and Tellis, 2000). Firm size and firm age were measured respectively by the total sales of each company and the number of years since its establishment. These details were collected from publicly available sources. The respondents assessed the R&D intensity as the percentage of R&D expenses relative to the sales of the focal firm in 2009. In cases of missing information in this regard, an industry-specific median value was used. To ensure sufficient normality of the distributions of the control variables, logarithm transformation was conducted for R&D Intensity variable.

As the survey data were collected from a single informant representing each firm, this presented the potential problem of common method variance. We tested this using Harman's one-factor test (Podsakoff *et al.*, 2003). All continuous variables were inserted into the exploratory factor analysis, and the unrotated factor solution showed that the largest factor accounted for 46% of the variance. However, this factor consisted only of the three items for external knowledge

sharing, in line with the conceptual rationale of the measure. Thus, we expect that common method variance would not be a major concern for this study.

4. Results

We utilized Partial least squares (PLS) structural equation modeling (SEM) technique, using SmartPLS version 3.0 to analyze the results. Such as any SEM method, PLS helps to analyze structural measurement models and related paths, and also provides factor loadings similar to principal component analysis (see e.g. Sosik *et al.*, 2009). Thus, PLS allows us to examine both the validity of the research model, as well as to analyze the empirical model in terms of hypothesized relationships and their significance. PLS has several particular benefits over other potential structural modeling methods (see e.g., Hair *et al.*, 2013). First, it allows for examining variables with non-normal distributions, such as in the case of our innovation performance measures. Second, PLS works well for path model estimations also for sufficiently small sample sizes relative to the research model complexity (such as in our case $n = 150$).

Appendix A shows the factor loadings, Average Variance Extracted (AVE), and Construct Reliability (CR) scores for the two multi-item constructs used in this study (knowledge sharing openness and accidental knowledge leakage). The factor loadings are all highly significant, supporting their relationships with the specific constructs. Furthermore, the construct reliabilities demonstrate high levels of reliability, with the CR values well above the threshold 0.7 (Bagozzi and Yi, 1991), and the AVE scores also exceeded the threshold of 0.50 (Fornell and Larcker, 1981). Altogether, we can state that reliability and validity for the measures are in a satisfactory level. Table 2 reports the descriptive statistics and correlations of the continuous variables used in the study. In addition, it allows us to further assess the discriminant validity statistics between the multi-item constructs (knowledge sharing openness and accidental knowledge leakage). In this assessment, we examine whether the square roots of AVEs are greater than the correlation of these constructs to others in the model (Fornell and Larcker, 1981). This condition is fulfilled in the model, as shown in Table 2 for the first two items (highlighted with bold face and italics).

Table 2 Descriptive statistics, correlations, and discriminant validity of the measures

<i>Variable</i>	<i>Mean</i>	<i>S.D.</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>
1. External knowledge sharing	2.83	1.41	0.93					
2. Accidental knowledge leakage	2.49	1.38	0.35**	0.96				
3. Incremental innovation performance	25.62	24.47	-0.16*	-0.04	a			
4. Radical innovation performance	9.60	15.98	-0.12	-0.18**	0.06	a		
5. Firm age	18.93	14.51	0.13	0.15*	-0.04	0.09	a	
6. Firm size (MEur)	42.06	174.07	-0.16*	-0.09	-0.00	0.02	0.03	a
7. R&D intensity (Ln)	0.60	2.20	-0.06	0.02	0.23**	0.21**	0.08	0.00

Notes: * $p < 0.1$; ** $p < 0.05$; (two-tailed); a = single-item indicator

Tables 2 reports the results of a Partial Least Squares path model analyses which includes all variables in the same model: control variables, the independent variable (knowledge sharing openness), the mediator (accidental knowledge leakage), as well as two dependent variables (incremental and radical innovation performance). This allows us to test our hypothesized model on radical innovation (H1), while also testing whether the model holds for incremental innovation (H2) to the same extent. Table 3 provides path coefficient estimates along with their t-values for each individual path. The results show that full mediation is supported for radical innovation performance. Another notable result is that we fail to obtain similar results for incremental innovation performance. Thus, we can conclude that our hypothesis 1 for the mediating model is supported in terms of radical innovation performance and that this effect is robust in that it does not appear to take place in the incremental innovation context (supporting hypothesis 2).

Table 3 Results for PLS path model

Path	Path coefficient	t-value
<i>Mediation model paths for incremental innovation performance</i>		
Uncontrolled external kn. sharing → Incremental innovation	-.054	0.620
Uncontrolled external kn. sharing → Accidental knowledge leakage	.350**	4.244
Accidental knowledge leakage → Incremental innovation	-.023	0.240
<i>Mediation model paths for radical innovation performance</i>		
Uncontrolled external kn. sharing → Radical innovation	-.038	0.463
Uncontrolled external kn. sharing → Accidental knowledge leakage	.350**	4.244
Accidental knowledge leakage → Radical innovation	-.161**	2.118
<i>Paths for control variables (Incremental innovation performance)</i>		
Firm size → Incremental innovation	.008	0.076
Firm age → Incremental innovation	-.018	0.249
R&D intensity → Incremental innovation	.200	1.405
Consulting engineering industries → Incremental innovation	.051	0.632
Electronics/electrotech. industries → Incremental innovation	-.041	0.480
Information technology industries → Incremental innovation	.285**	2.901
<i>Paths for control variables (Radical innovation performance)</i>		
Firm size → Radical innovation	-.041	0.288
Firm age → Radical innovation	.136	1.336
R&D intensity → Radical innovation	.125	1.405
Consulting engineering industries → Radical innovation	.056	0.865
Electronics/electrotech. industries → Radical innovation	.187*	1.741
Information technology industries → Radical innovation	.118	1.257
<i>Coefficient of determination (R²)</i>		
Incremental innovation performance	0.15	
Radical innovation performance	0.11	

Notes: * p < 0.1; ** p < 0.05; (two-tailed)

5. Discussion and implications

Sharing knowledge with external partners is a key issue in collaborative innovation and a necessary process for firms pursuing to reap the benefits of innovation (Trott and Hartmann, 2009; Tranekjer and Knudsen, 2012; West and Bogers, 2014). However, several studies have shown that excessive knowledge exchange may be unproductive or lead to negative consequences due to knowledge redundancy, spillovers, or other “dark sides” of innovation (Frishammar *et al.*, 2015; Hoecht and Trott, 1999, 2006; Norman, 2004; Trott and Hartmann, 2009). The risks are especially pronounced regarding radical innovation outcomes, since a firm’s proprietary knowledge related to radical innovation tends to lose its value if it is diffused too widely (e.g. Li *et al.*, 2008). While this intuition is well-grounded, we identified a clear research gap in the current literature regarding

the lack of empirical evidence on the linkages between inter-firm knowledge sharing, leakage, and radical innovation outcomes.

Our empirical results based on a PLS model of 150 firms show that the uncontrolled external sharing of business-critical knowledge is harmful to a firm's radical innovation performance, and this effect is mediated through accidental knowledge leakage. The same mediating effect did not get support in the case of incremental innovations. Thus, the results compel us to suggest that business-critical knowledge should not be shared too openly or uncritically if the focal firm is specifically pursuing radical innovations. Rather, more selective and focused knowledge sharing can ensure that business-critical knowledge is not accidentally leaked to too many people in the partner organization(s) and eventually to competitors. These results highlight a striking difference between how innovation outcomes are affected by knowledge leakage: incremental innovation does not suffer from knowledge leakage that much, while for radical innovation, the downsides are substantial. While not counter-intuitive, these results are original as existing research has provided scant empirical evidence of this phenomenon. We therefore believe they provide important implications for research as well as managerial practice. We discuss those next and outline the limitations of our research, and suggest future research directions.

5.1. Theoretical implications

The literature on collaborative innovation has focused heavily on the positive aspects of external collaboration and knowledge sharing, leaving the potential downsides largely unexplored (Knudsen and Mortensen, 2011). Especially research on knowledge leakage still appears to be at a nascent stage of development (Ahmad *et al.*, 2014; Durst *et al.*, 2015). Our study provides evidence of these downsides especially in the radical innovation context. While the literature has indeed noted the existence of potential disadvantages and risks (Dahlander and Gann, 2010; Laursen and Salter, 2014; Trott and Hartmann, 2009), our study provides a new, more comprehensive understanding of the important issue of the specific risks related to the nature of the individual-level knowledge-sharing process (uncontrolled vs. selective) and the resulting unintentional knowledge leakage that can take place in inter-firm knowledge-sharing contexts. Thus, our results complement the literature that has recognized the need for a firm to control and manage external knowledge flows to achieve positive innovation outcomes (Alexy *et al.*, 2013;

Henkel, 2006). Furthermore, our focus on sharing knowledge with the firm's partners has enabled us to contribute to the limited yet growing discussion on the knowledge provider's side of collaborative innovation (Tranekjer and Knudsen, 2012).

Our results also contribute to the emerging literature on knowledge leakage within the broader body of research on inter-organizational knowledge sharing. Recent studies examining knowledge leakage in the collaborative R&D and innovation context (Frishammar *et al.*, 2015; Ritala *et al.*, 2015) have shown that knowledge leakage can be detrimental to a firm's innovation performance. Our study complements these insights by offering a more nuanced understanding of the phenomenon in the radical innovation context, especially by underlining the role of employee decisions in what knowledge to share and with whom to share it. Our results support the argument that understanding employee behavior is important for examining why business-critical knowledge leaks and how it can be protected (Baughn *et al.*, 1997; Hannah and Robertson, 2015); accordingly, they respond to the calls for research into the roles of individuals in the knowledge-sharing interface (Foss *et al.*, 2010; Ghosn and Rosenkopf, 2015; Salter *et al.*, 2015). For instance, research has shown that the employees' acknowledgment and willingness to follow guidance on these issues can vary (Olander and Hurmelinna-Laukkanen, 2015), and they might bend rules for the sake of good collaboration (Hannah and Robertson, 2015), which could have critical effects in terms of leakage if they do not use good judgment. As we have shown, this problem is especially relevant for firms pursuing radical innovations.

Second, our study contributes to the literature on innovation appropriability in alliances and networks (Dhanaraj and Parkhe, 2006; Laursen and Salter, 2014). Our results demonstrate how novel knowledge combinations lose their value if knowledge is spread too widely in the collaborative interface. The more complex and networked the context of the innovation activities is, the more care must be exercised in the process of sharing knowledge relating to radical innovation to ensure the appropriability of the related value.

5.2. Practical implications

Our analysis provides a set of implications for managers working in companies that pursue both radical and incremental innovation goals. The key finding that radical innovation performance suffers when employees accidentally leak business-critical knowledge should be taken seriously. While knowledge sharing is needed for external partnerships to work, an excessively open

approach may become counterproductive for an organization aiming to reap the advantages of its radical ideas. In this regard, we found that when firms do not control well the knowledge they share in external collaborations, it leads to accidental knowledge leakage. Therefore, effective contractual and relational practices are required in firms participating in external collaborations, to ensure that employees exercise careful judgment when sharing knowledge with partners. At firm-level, these practices might include non-disclosure agreements, patents and other intellectual property rights, guidelines for sharing and protecting proprietary knowledge, as well as technical barriers to exclude some parts of radical innovation-related knowledge. In the partnership context, useful practices include alliance contracts (related to what intellectual property belongs to whom), joint principles for knowledge sharing among contact persons, as well as clear rules regarding the type of knowledge that should not be communicated.

On the other hand, when incremental innovations are being developed within a firm, sharing some knowledge about these innovations might not be too harmful. Indeed, our results suggest that firms need not to be overly worried of accidental knowledge leakage, since individual revelations of incremental developments do not carry such risk of exposing the best kept in-house secrets. However, for incremental innovation, fully uncontrolled knowledge sharing is likely not to be optimal either. Therefore, managers could determine the means for exercising a suitable level of control that provides the best results for innovation performance, depending on the radicalness of the innovation as well as the distinct features of that innovation (e.g. are some ideas especially vulnerable for outside exposure).

Finally, in some cases, “selective revealing” of knowledge (see e.g. Alexy *et al.*, 2013) could even generate positive outcomes. Firms should consider which elements of their innovation are such that they could be revealed to collaboration partners as well as more broadly in a way that provides benefits for the firm. Those benefits might include increasing reciprocity from external parties that enable to develop the innovation further, as well as brand and reputation benefits as the information from the innovation is disseminated in the markets and among prospective customers.

5.3. Limitations and future research

Our study has several limitations that should be accounted for when interpreting the results. We focused explicitly on the firm possessing the knowledge and its employees’ knowledge sharing

behavior; we did not consider the complexity of collaborative innovation beyond this focus. For instance, we did not examine the role and behavior of the knowledge recipient firm. Further, we did not differentiate between different types of inter-firm collaborative projects, which can have a significant influence on the phenomenon under study. We see potential in investigating how these issues modify the relationships between external knowledge sharing and radical innovation that we have proposed.

Furthermore, our study faced limitations regarding the data collection procedure (cross-sectional survey design) as well as the overall research design (measures and approaches). We encourage further research examining not only individual employees' decisions but also what influences these decisions. For example, various important factors are likely to affect the uncontrolled openness of external knowledge sharing, including those within and beyond the employees' own judgment. Employee-related factors could further relate to the motivations behind knowledge sharing and leakage, as well as other issues associated with the knowledge-sharing behavior, scope and context. For instance, important issues include organization-level education, systems, and codes of conduct linked to knowledge sharing and protection, as well as the organizational culture toward openness. Furthermore, future research could focus on inter-partner dynamics in collaborative innovation and how these affect knowledge leakage and its consequences for the firms involved in the collaboration. For instance, it has been suggested that organizations that are weaker in innovative knowledge assets strive to gain access to such assets by collaborating with stronger partners (Alexy *et al.*, 2013; Kale and Singh, 2009), and that such organizations might act in an opportunistic manner in those relationships (Liebeskind, 1996; Teece, 2002). Alternatively, stronger firms could be expected to use their bargaining power to their advantage and distill relevant knowledge from the weaker partner. Finally, our research relies on perceptual measures in addressing the issues of knowledge sharing, leakage, and innovation performance. Future studies – both qualitative and quantitative – could develop alternative and more nuanced and accurate ways to measure knowledge that is leaked, and connect them with implications to focal firm innovation. We hope that future studies will build on our work by examining these issues.

6. Concluding remarks

In this study we examined how sharing of business-critical knowledge with external collaboration partners affects firm's radical innovation performance. We started with the assumption that there is a "dark side of openness" when it comes to external collaboration. This is related to the possibility of business-critical knowledge leaking outside firm boundaries, risking the novelty value of radical innovations. Using the dataset of 150 CEOs from Finnish technology industries, we found that the aforementioned risk is true. Uncontrolled sharing of knowledge among external collaboration partners leads to higher possibility of accidental knowledge leakage, which is negatively associated with firm's radical innovation performance. Knowledge leakage did not similarly hurt incremental innovation performance, which further suggests that the risks of leakage relate most often to radical innovation. Based on the study, we can conclude that managers and experts should think carefully what type of knowledge is shared in external collaborations, with whom it is shared, and who is sharing it. Collaborative innovation is an increasing trend across industries, and researchers and practitioners are well advised to recognize not only the benefits of external knowledge sharing, but also its downsides.

References

- Abernathy, W.J. and Clark, K.B. (1985), "Innovation: Mapping the winds of creative destruction", *Research Policy*, Vol. 14 No. 1, pp. 3-22.
- Ahmad, A., Bosua, R. and Scheepers, R. (2014), "Protecting organizational competitive advantage: a knowledge leakage perspective", *Computers & Security*, Vol. 42 May, pp. 27-39.
- Alexy, O., George, G. and Salter, A.J., (2013), "Cui bono? The selective revealing of knowledge and its implications for innovative activity", *Academy of Management Review*, Vol. 38 No. 2, pp. 270-291.
- Alexy, O., West, J., Klapper, H. and Reitzig, M. (2017). "Surrendering control to gain advantage: reconciling openness and the resource-based view of the firm". *Strategic Management Journal*. Article in press, available online. DOI: 10.1002/smj.2706
- Anuaimi, T. and George, G. (2016), "Appropriability and the retrieval of knowledge after spillovers", *Strategic Management Journal*, Vol. 37 No. 7, pp. 1263-1279.

- An, X., Deng, H., Chao, L. and Bai, W. (2014), "Knowledge management in supporting collaborative innovation community capacity building", *Journal of Knowledge Management*, Vol. 18 No. 3, pp. 574-590.
- Arora, A., Athreye, S. and Huang, C. (2016), "The paradox of openness revisited: Collaborative innovation and patenting by UK innovators", *Research Policy*, Vol. 45 No. 7, pp. 1352-1361.
- Bagozzi, R.P. and Yi, Y. (1991), "Multitrait-multimethod matrices in consumer research", *Journal of Consumer Research*, Vol. 17 No. 4, pp. 426-439.
- Bartholomew, S. and Smith, A. D. (2006). "Improving survey response rates from chief executive officers in small firms: The importance of social networks". *Entrepreneurship Theory and Practice*, Vol. 30 No. 1, pp. 83-96.
- Baughn, C.C., Denekamp, J.G., Stevens, J.H. and Osborn, R.N. (1997), "Protecting intellectual capital in international alliances", *Journal of World Business*, Vol. 32 No. 2, pp. 103-117.
- Belderbos, R., Carree, M. and Lokshin, B. (2004), "Cooperative R&D and firm performance", *Research Policy*, Vol. 33 No. 10, pp. 1477-1492.
- Bogers, M. (2011), "The open innovation paradox: Knowledge sharing and protection in R&D collaborations", *European Journal of Innovation Management*, Vol. 14 No. 1, pp. 93-117.
- Brown, B. (2010), "Why innovation matters", *Research - Technology Management*, Vol. 53 No. 6, pp. 18-23.
- Chandy, R.K. and Tellis, G.J. (2000), "The incumbent's curse? Incumbency, size, and radical product innovations", *Journal of Marketing*, Vol. 64 No. 3, pp. 1-17.
- Chesbrough, H.W. (2006), *Open business models: How to thrive in the new innovation landscape*. Harvard Business School Press, Cambridge, MA.
- Cohen, W.M., Goto, A., Nagata, A., Nelson, R. and Walsh, J.P. (2002), "R&D spillovers, patents and the incentives to innovate in Japan and the United States", *Research Policy*, Vol. 31 No. 8, pp. 1349-1367.
- Connell, J., Kriz, A. and Thorpe, M. (2014), "Industry clusters: an antidote for knowledge sharing and collaborative innovation?" *Journal of Knowledge Management*, Vol. 18 No 1, pp. 137-151.
- Dahlander, L. and Gann, D.M. (2010), "How open is innovation?", *Research Policy*, Vol. 39 No. 6, pp. 699-709.

- Delgado-Verde, M., Navaz-López, J. E., Cruz-González, J. and Amores-Salvadó, J. (2011). "Radical innovation from relations-based knowledge: empirical evidence in Spanish technology-intensive firms", *Journal of Knowledge Management*, Vol. 15 No 5, pp. 722-737.
- Dhanaraj, C. and Parkhe, A. (2006), "Orchestrating innovation networks", *Academy of Management Review*, Vol. 31 No. 3, pp. 659-669.
- Durst, S., Aggestam, L. and Ferenhof, H.A. (2015), "Understanding knowledge leakage: a review of previous studies", *VINE*, Vol. 45 No. 4, pp. 568-586.
- Dyer, J.H. and Nobeoka, K. (2000), "Creating and managing a high-performance knowledge-sharing network: The Toyota case", *Strategic Management Journal*, Vol. 21 No. 3, pp. 345-367.
- Ethiraj, S.K., Levinthal, D. and Roy, R.R. (2008), "The dual role of modularity: Innovation and imitation", *Management Science*, Vol. 54 No. 5, pp. 939-955.
- Federation of Finnish Technology Industries, (2014), Available at: <http://www.teknologiateollisuus.fi/en/>
- Fornell, C., Larcker, D.F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, pp. 39-50.
- Foss, N. J., Husted, K. and Michailova, S. (2010), "Governing knowledge sharing in organizations: Levels of analysis, governance mechanisms, and research directions", *Journal of Management Studies*, Vol. 47 No. 3, pp. 455-482.
- Frishammar, J., Ericsson, K. and Patel, P.C. (2015), "The dark side of knowledge transfer: Exploring knowledge leakage in joint R&D projects", *Technovation*, Vol. 41-42 pp. 75-88.
- Fugate, B.S., Stank, T.P. and Mentzer, J.T. (2009), "Linking improved knowledge management to operational and organizational performance", *Journal of Operations Management*, Vol. 27 No. 3, pp. 247-264.
- Ghosn, A. and Rosenkopf, L. (2015), "Shrouded in structure: Challenges and opportunities for a friction-based view of network research", *Organization Science*, Vol. 26 No. 2, pp. 622-631.
- Hair, J. F., Hult, G. T. M., Ringle, C. and Sarstedt, M. (2013), *A primer on partial least squares structural equation modeling (PLS-SEM)*. Thousand Oaks, CA: Sage Publications.
- Hannah, D.R. (2005), "Should I keep a secret? The effects of trade secret protection procedures on employees' obligations to protect trade secrets", *Organization Science*, Vol. 16 No. 1, pp. 321-347.

- Hannah, D.R. and Robertson, K. (2015), "Why and how do employees break and bend confidential information protection rules?", *Journal of Management Studies*, Vol. 52 No. 3, pp. 381–413.
- Heiman, B. and Nickerson, J., (2004), "Empirical evidence regarding the tension between knowledge sharing and knowledge expropriation in collaborations", *Managerial and Decision Economics*, Vol. 25 No. 6-7, pp. 401–420.
- Henkel, J. (2006), "Selective revealing in open innovation processes: The case of embedded Linux", *Research Policy*, Vol. 35 No. 7, pp. 953–969.
- Hernandez, E., Sanders, W.M.G. and Tuschke, A. (2015), "Network defense: Pruning, grafting, and closing to prevent leakage of strategic knowledge to rivals", *Academy of Management Journal*, Vol. 58 No. 4, pp. 1233–1260.
- Hoecht, A. and Trott, P. (1999), "Trust risk and control in the management of collaborative technology development", *International Journal of Innovation Management*, Vol. 3 No. 3, pp. 257–270.
- Hoecht, A. and Trott, P. (2006), "Outsourcing, information leakage and the risk of losing technology-based competencies", *European Business Review*, Vol. 18 No. 5, pp. 395–412.
- Hoetker, G. and Agarwal, R. (2007), "Death hurts, but it isn't fatal: The postexit diffusion of knowledge created by innovative companies", *Academy of Management Journal*, Vol. 50 No. 2, pp. 446–467.
- Husted, K. and Michailova, S. (2010), "Dual allegiance and knowledge sharing in inter-firm R&D collaborations", *Organizational Dynamics*, Vol. 39 No. x, pp. 37–47.
- Husted, K., Michailova, S. and Olander, H. (2013), "Dual allegiance, knowledge sharing, and knowledge protection: An empirical examination", *International Journal of Innovation Management*, Vol. 17, No 1340022.
- Jansen, J.J.P., van Den Bosch, F.A.J. and Volberda, H.W. (2006), "Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators", *Management Science*, Vol. 52 No. 11, pp. 1661–1674.
- Jiang, X., Li, M., Gao, S., Bao, Y. and Jiang, F. (2013), "Managing knowledge leakage in strategic alliances: The effects of trust and formal contracts", *Industrial Marketing Management*, Vol. 42 No. 6, pp. 983-991.

- Järvenpää, S.L. and Majchrzak, A., (2016), “Interactive self-regulatory theory for sharing and protecting in interorganizational collaborations”, *Academy of Management Review*, Vol. 41 No. 1, pp. 9-27.
- Kale, P., Singh, H. and Perlmutter, H. (2000), “Learning and protection of proprietary assets in strategic alliances: Building relational capital”, *Strategic Management Journal*, Vol. 21 No. 3, pp. 217–237.
- Kale, P. and Singh, H. (2009), “Managing strategic alliances: What do we know now, and where do we go from here?” *Academy of Management Perspectives*, Vol. 23 No. 3, pp. 45–82.
- Katila, R., Rosenberger, J.D. and Eisenhardt, K.M. (2008), “Swimming with sharks: Technology ventures, defense mechanisms and corporate relationships”, *Administrative Science Quarterly*, Vol. 53 No. 2, pp. 295–332.
- Keizer, J.A. and Halman, J.I.M. (2007), “Diagnosing risk in radical innovation projects”, *Research-Technology Management*, Vol. 50 No. 5, pp. 30–36.
- Knudsen, M.P. and Mortensen, T.B., (2011), “Some immediate – but negative – effects of openness on product development performance”, *Technovation*, Vol. 31 No. 1, pp. 54–64.
- Kumar, N., Stern, L. and Anderson, J. (1993), “Conducting interorganizational research using key informants”, *Academy of Management Journal*, Vol. 36 No. 6, pp. 1633–1651.
- Laursen, K. and Salter, A.J. (2014), “The paradox of openness: Appropriability, external search and collaboration”, *Research Policy*, Vol. 43 No. 5, pp. 867–878.
- Lazarotti, V., Manzini, R. and Pellegrini, L. (2011), “Firm-specific factors and the openness degree: A survey of Italian firms”, *European Journal of Innovation Management*, Vol. 14 No. 4, pp. 412–434.
- Li, D., Eden, L., Hitt, M.A. and Ireland, R.D. (2008), “Friends, acquaintances, or strangers? Partner selection in R&D alliances”, *Academy of Management Journal*, Vol. 51 No. 2, pp. 315–334.
- Liebeskind, J.P. (1996), “Knowledge, strategy and the theory of the firm”, *Strategic Management Journal*, Vol. 12 No. 2, pp. 93–107.
- Lin, H.F. (2007), “Knowledge sharing and firm innovation capability: An empirical study”, *Journal of Manpower*, Vol. 28 Nos 3/4, pp. 315-332.
- Manhart, M. and Thalmann, S. (2015), “Protecting organizational knowledge: a structured literature review”, *Journal of Knowledge Management*, Vol. 19 No. 2, pp. 190-211.

- Mata, J. and Woerter, M. (2013), "Risky innovation: The impact of internal and external R&D strategies upon the distribution of returns", *Research Policy*, Vol. 42 No. 2, pp. 495–501.
- McFadyen, M.A. and Cannella, A.A. (2004), "Social capital and knowledge creation: Diminishing returns of the number and strength of exchange relationships", *Academy of Management Journal*, Vol.47 No. 5, pp. 735–746.
- Norman, P.M. (2002), "Protecting knowledge in strategic alliances, resource and relational characteristics", *Journal of High Technology Management Research*, Vol. 13 No. 2, pp. 177–202.
- Norman, P.M. (2004), "Knowledge acquisition, knowledge loss and satisfaction in high technology alliances", *Journal of Business Research*, Vol. 57 No. 6, pp. 610–619.
- O'Connor, G.C. and Rice, M.P. (2013), "A comprehensive model of uncertainty associated with radical innovation", *Journal of Product Innovation Management*, Vol. 30 No. S1, pp. 2–18.
- Olander, H., Hurmelinna-Laukkanen, P. and Heilmann, P. (2011), "Do SMEs benefit from HRM-related knowledge protection in innovation management?", *International Journal of Innovation Management*, Vol. 15 No. 3, pp. 593–616.
- Olander, H. and Hurmelinna-Laukkanen, P. (2015), "Perceptions on employee knowledge-risks in multinational, multilevel R&D organizations – managing knowledge leaking and leaving", *International Journal of Innovation Management*, Vol. 19, 1540006.
- Oxley, J.E. and Sampson, R.C. (2004), "The scope and governance of international R&D alliances", *Strategic Management Journal*, Vol. 25 No. 8-9, pp. 723–749.
- Pahnke, E., McDonald, R., Wang, D. and Hallen, B. (2015), "Exposed: Venture capital, competitor ties, and entrepreneurial innovation", *Academy of Management Journal*, Vol. 58 No. 5, pp. 1334-1360.
- Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y. and Podsakoff, N.P. (2003), "Common method biases in behavioral research: A critical review of the literature and recommended remedies", *Journal of Applied Psychology*, Vol. 88 No. 5, pp. 879–903.
- Ponce, C.J. (2011), "Knowledge disclosure as intellectual property rights protection", *Journal of Economic Behavior and Organization*, Vol. 80 No. 3, pp. 418–434.
- Ritala, P. and Hurmelinna-Laukkanen, P. (2013), "Incremental and radical innovation in coopetition – The role of absorptive capacity and appropriability", *Journal of Product Innovation Management*, Vol. 30 No. 1, pp. 154-169.

- Ritala, P., Olander, H., Michailova, S. and Husted, K. (2015), "Knowledge sharing, knowledge leaking and relative innovation performance: An empirical study", *Technovation*, Vol. 35, pp. 22–31.
- Salter, A., Ter Wal, A.L.J., Criscuolo, P. and Alexy, O. (2015), "Open for ideation: Individual-level openness and idea generation in R&D", *Journal of Product Innovation Management*, Vol. 32 No. 4, pp. 488–504.
- Schoenmakers, W. and Duysters, G. (2010), "The technological origins of radical inventions", *Research Policy*, Vol. 39 No. 8, pp. 1051-1059.
- Scotchmer, S. and Green, J. (1990), "Novelty and disclosure in patent law", *The RAND Journal of Economics*, Vol. 21 No. 1, pp. 131–146.
- Serenko, A. and Bontis, N. (2016), "Negotiate, reciprocate, or cooperate? The impact of exchange modes on inter-employee knowledge sharing", *Journal of Knowledge Management*, Vol. 20, No 4, pp. 687–712.
- Sosik, J., Kahai, S. and Piovoso, M. (2009), "Silver bullet or voodoo statistics? A primer for using the partial least squares data analytic technique in group and organization research", *Group and Organization Management*, Vol. 34 No. 5, pp. 5–36.
- Stenius, M, Hankonen, N., Ravaja, N. and Haukkala, A. (2016), "Why share expertise? A closer look at the quality of motivation to share or withhold knowledge", *Journal of Knowledge Management*, Vol. 20 No. 2, pp. 181–198.
- Stringer, R. (2000), "How to manage radical innovation", *California Management Review*, Vol. 42 No. 4, pp. 70–88.
- Subramaniam, M. and Youndt, M.A. (2005), "The influence of intellectual capital on the types of innovative capabilities", *Academy of Management Journal*, Vol. 48 No. 3, pp. 450–463.
- Teece, D.J. (1986), "Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy", *Research Policy*, Vol. 15 No. 6, pp. 285–305.
- Teece, D.J. (2002), *Managing intellectual capital*. Oxford: Oxford University Press.
- Tomlinson, P.R. (2010), "Co-operative ties and innovation: Some new evidence for UK manufacturing", *Research Policy*, Vol. 39 No. 6, pp. 762–775.
- Tranekjer, T.L. and Knudsen, M.P. (2012), "The (unknown) providers to other firms' new product development: What's in it for them?", *Journal of Product Innovation Management*, Vol. 29 No. 6, pp. 986–999.

- Trott, P. and Hartmann, D., (2009), “Why open innovation is old wine in new bottles”, *International Journal of Innovation Management*, Vol.13 No. 4, pp. 715–736.
- Tushman, M. and Anderson, P. (1986), “Technological discontinuities and organizational environments”, *Administrative Science Quarterly*, Vol. 31 No. 3, pp. 439–465.
- van Dijk, E. and Wilke, H.A.M. (2000), “Decision-induced focusing in social dilemmas: Give-some, keep-some, take-some, and leave-some dilemmas”, *Journal of Personality and Social Psychology*, Vol. 78 No. 1, pp. 92–104.
- van Dijk, A., Hendriks, P. and Romo-Leroux, I. (2016), “Knowledge sharing and social capital in globally distributed execution”, *Journal of Knowledge Management*, Vol. 20 No. 2, pp. 327-343.
- Wenger, E.C. and Snyder, W.M. (2000), “Communities of practice: The organizational frontier”, *Harvard Business Review*, Vol. 78 No. 1, pp. 139–145.
- West, J. and Bogers, M. (2014), “Leveraging external sources of innovation: A review of research on open innovation”, *Journal of Product Innovation Management*, Vol. 31 No. 4, pp. 814–831.
- Yang, H., Phelps, C. and Steensma, K. (2010), “Learning from what others have learned from you: The effects of knowledge spillover on originating firms”, *Academy of Management Journal*, Vol. 54 No. 2, pp. 371-389.

Acknowledgements

We would like to thank the Tekes (Finnish Funding Agency for Innovation) for financial support that made conducting this research possible.

Appendix A: Constructs and measurement items

Construct	Item	Factor loading	AVE	CR	
Uncontrolled external knowledge sharing*	When an employee in our company becomes aware of important business critical information (related to the context of a specific partnership), he or she typically... (1 – 7 point scale)		0.859	0.948	
	*The measure is reversed. This means that the higher the score in the measure, the more open/uncontrolled the knowledge sharing is. The lower the score is the more focused, selective, and controlled the sharing is	Quickly shares it with the partner's contact personnel Shares it only with the appropriate contact persons of the business partner	0.950***		
		Quickly shares it with the business partner's other functional departments/teams Shares it only with the appropriate functional departments/teams of the business partner	0.959***		
		Quickly shares it with the business partner's senior management Shares it only with the appropriate senior managers of the business partner	0.868***		
Accidental knowledge leakage	How well do the following statements characterize your company's personnel? (1= completely disagree, 7=completely agree)		0.927	0.962	
		Our employees accidentally leak business critical knowledge to our partners	0.957***		
		Our employees accidentally leak business critical knowledge in other situations	0.968***		
Radical and incremental innovation performance*	Please estimate how your total turnover in 2011 was distributed between the categories below				
	*Response was asked in the form of percentages, with an advise that overall distribution should be total of 100%	Products/services introduced in 2009–2011 that were completely new (radical innovations)			
		Products/services introduced in 2009–2011 that were improved (incremental innovations)			
	Products/services that have practically been unchanged in the last three years				

*** $p < 0.01$ (two-tailed)