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Infringement of Intellectual Property in Innovation Partnerships

Torben Schubert (torben.schubert@isi.fraunhofer.de)
CIRCLE, Lund University & Fraunhofer ISI, Karlsruhe, Germany

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Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

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Abstract
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JEL codes: O32, O34

Keywords: infringement, intellectual property, innovation, partnerships, alliances, protection

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Torben Schubert

CIRCLE, Lund University, Sölvegatan 16, 22100 Lund, Sweden

Fraunhofer ISI, Breslauer Straße 48, 76135 Karlsruhe, Germany

email: torben.schubert@isi.fraunhofer.de

tel.: +49 721 6809 357

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1 Introduction

Alliances among firms allow for the mutual exploitation of knowledge and know-how complementarities between firms, risk reduction, sharing of investment burdens and increasing market reach. Despite these alleged advantages, reality has shown high failure rates in alliances, which are often more than 50% (Harrigan 1988, Parkhe 1993).

To explain these failures many authors have invoked the concept of opportunism defined as "self-interest seeking with guile" (Williamson 1975). In practice this means that opportunistic actors maximize their own utility also at the expense of their partners (Chiesa and Manzini 1998, Kogut 1988, Hamel 1991, Parkhe 1993, Gulati 1999, Deeds and Hill 1998, Dickson et al. 2006, Das and Rahman 2010, Enkel et al. 2005).

At the same time the influential relational alliance literature seems to turn away from the focus on opportunism proposing that the very roots of opportunism can be eliminated through socio-relational mechanisms, such as trust, relational capital and reputation (e.g. Bucklin and Sengupta 1993, Judge and Dooley 2006, Anand and Khanna 2000, Feller 2013).

While this would suggest that the emphasis on opportunism is overstated, Carson et al. (2006) make a convincing point that relational mechanisms can be quite ineffective when the ultimate goal of the alliance is not easily measurable. This reasoning builds on the observation that also relational mechanisms are based on social sanctions, whose legitimate exertion requires an unambiguous measurement of the final alliance outputs. If this is not possible, the decision to sanction certain behaviors (or not) is prone to errors and thus will become ineffective. Carson et al. (2006) refer to this as the problem of ambiguity. Thus the argument that relational mechanisms eradicate opportunism altogether might be overly optimistic in situations of output ambiguity. Based on this our basic assumption is that opportunism may still be an important issue in alliances.

The ambiguity argument is obviously the more convincing the less measureable the alliance outputs are. Therefore we investigate this hypothesis based on a special form of alliance: namely the innovation partnership, which by aiming at knowledge generation is very likely to produce intangible and tacit outputs that are difficult to observe. A further reason which makes the innovation partnership appealing in our context is that it allows us to derive a natural operationalization of the abstract concept of opportunism. This is because innovation partnerships require the mutual disclosure of key knowledge assets, which might then be opportunistically appropriated by the partners. Correspondingly, one of the most important instances of opportunistic behaviors in this context is the infringement of intellectual property (IP), taking the form of unauthorized use or copying of IP possessed by the partners.

The second aim of this paper is the analysis of the effectiveness of protection mechanisms that can reduce this infringement risk. We have already argued that relational mechanisms may not be effective in cases of great ambiguity. This raises the question of alternative mechanisms. An obvious candidate is the use of formal protection mechanisms[1], such as patents or contracts. While these mechanisms have their own problems – in particular their commonly alleged incompleteness (Joskov, 1987, Kloyer and Scholderer 2011, Lemley and Shapiro 2005) – we argue that their two key advantages derive from the fact that formal protection mechanisms entail a process of codification, which makes the underlying knowledge assets observable. This allows first to mitigate the ambiguity problem pertaining and second to facilitate the clear attribution of knowledge assets to those partners who bring them into the partnership. Despite the more or less implicit pessimism about the effectiveness of formal protection mechanisms encountered in the alliance literature we therefore hold that they can significantly reduce the risk of IP infringement.

Making use of the German part of Community Innovation Surveys (CIS) for 2007 covering about 7,000 firms from almost all sectors, the main results are that entering innovation partnerships increases the hazard of infringement of all types of IP except brands and names. Most strongly effected is the copying of products with an implied risk increase of 4 percentage points, which, compared to the average risk of 10.8%, corresponds to an increase of 37%. This is followed by infringement concerning technical inventions (increase of 2.4%), copying of designs (1.3%). We show that contractual set-ups for organizing innovation partnerships and formal IP rights can reduce the risk of infringement, but as expected they do not eliminate the roots of opportunism. We demonstrate this by the finding that the higher risks are usually due to an overall increase in the legal infringement of IP, implying that infringement in innovation partnerships more commonly refers to formally unprotected IP, i.e. cases of infringement where partners do not have to fear formal punishment.

We contribute to the literature both empirically and theoretically. From the empirical point of view we provide the first quantitative evidence on the impact of innovation partnering on the risk of IP infringement as well as on the mitigating role of formal protection mechanisms. These figures should be equally important for the IP-related as well as the alliance literature. From a theoretical perspective we point out that the risk of opportunism in innovation partnerships in general and IP infringement in particular should not be prematurely discarded. For this we develop and extend arguments related to the ambiguity problem associated with the unobservability of the partnership outputs. We also highlight that this line of reasoning foresees an important role for formal IP protection mechanisms in preventing opportunistic IP infringement. Based on

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1 Formal protection mechanisms are any protection mechanisms which confer legal rights to the owner of the IP, which can be defended through the legal system (Blind et al. 2006).

this we develop arguments that guide how relational and formal mechanisms can be combined to provide a more effective hedge against opportunistic threats in innovation partnerships.

2 Theory

2.1 Opportunism and IP infringement in innovation partnerships

Opportunism is frequently discussed as the source of alliance failures. The original definition of opportunism – "self-interest seeking with guile" (Williamson 1975) – makes clear that this concept refers to a behavioral assumption rather than to a concrete action. More precisely, opportunism is the claim that economic actors whose behavior is (socially, legally, or morally) unrestricted do not only seek to maximize their utility but will also resort to measures that are loosely speaking dishonest.

In the context of innovation partnerships, Hertzfeldt et al. (2006) argue that one of the most common forms of opportunism is IP infringement, i.e. the non-consented appropriation of key knowledge assets by partners, where we define IP as any knowledge asset which potentially confers economic value to its holder.[2] This is the case because the collaboration implies close interaction among the partners leading to the disclosure and sharing of core knowledge assets (c.f. Eisenhardt and Schoonhoven 1996, Deeds and Hill 1998, Oliver and Liebeskind 1998, Rothaermel and Deeds 2006). This paves the road for misappropriation of knowledge by partners. Thus, innovation partnering and R&D alliances have been characterized as creating a competition-cooperation dilemma (Faems et al. 2010).

With formal, informal and relational protection mechanisms there are three major approaches to prevent IP infringement as a special case of opportunistic behavior.

Formal protection mechanisms are mechanisms that can be used to protect IP by granting the holder legally enforceable rights. These rights can take one of two forms. First, there are *universal ownership rights*, which grant the right to exclude any other party from the use of the protected IP. Examples are copyrights, patents, registered brands or names. Second there are rights which only bind the parties who agree to them. These rights are typically in the form of *legally binding contracts*. Informal as opposed to formal protection mechanisms do not entail any legal rights. They work through some sort of de facto protection. Examples are secrecy and or lead-time. Relational protection mechanisms are based on the threat of social sanctioning. They neither build on any de facto protection (as informal protection) nor on legal rights. Examples are the loss of reputation or the termination of the partnership.

In particular in an innovation partnership relational and informal protection does not work properly. The former may not be effective to solve the opportunism threat because the desired

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2 The term property, however, should not indicate that legally enforceable property rights are necessarily associated with it. A mathematical formula for example might confer value when applied in its contexts, but it cannot be protected.

distribution of the generated IP is hard to control when the outputs are unobservable, which is a natural problem in knowledge creating activities. Carson et al. (2006) refer to this as the problem of ambiguity (or the metering problem). Furthermore, informal mechanisms become practically useless. This is the case because knowledge sharing is an essential part of innovation partnerships, but secrecy works by restricting knowledge flows (Jiang and Li 2009, Wittmann et al. 2009). Correspondingly, Hertzfeldt et al. (2006) find that firms entering innovation partnerships make much more intensive use of formal patent rights than of secrecy, whereas Jankowski (2012) reports that outside innovation partnerships the relative importance is reversed, rendering secrecy otherwise more important than patents.

Both the fact that innovation partnerships increase the access to the partners' IP and the fact that secrecy as well as relational mechanisms will be less ineffective should increase the hazard of IP infringement for firms entering such partnerships.

H1: Firms in innovation partnerships are more likely to experience infringement of their IP.

If H1 is true, this asks the question of how IP can be protected from infringement. We will discuss the role of formal protection mechanisms, which work through granting formal rights, in the next subsection.

2.2 The effectiveness of formal protection mechanisms in innovation partnerships

While there is a large literature on the role of legal IP protection mechanisms (Lanjouw and Schankerman 2004, Blind et al. 2006, James et al. 2013, Neuhäusler 2012) only anecdotal evidence exists on the effectiveness of formal protection mechanisms, which additionally is limited to patents. In this context Coy (1993) reported for example on an attorney of a computer manufacturer who stated that "Our patents can be a sword or a shield." Likewise Cohen et al. (2000) as well as von Hippel (1998) emphasize the great value of patents as threats in emerging litigation cases. Beyond such general statements, to date no quantitative evidence exists on the effectiveness of formal protection mechanisms, even less so in the special case of innovation partnering. In the following, we intend to explain the crucial importance of legal protection mechanisms in innovation partnerships and show why they can effectively complement relational mechanisms of avoiding opportunistic behavior and IP infringement such as relational capital (cf. Anand and Khanna 2000, Kale et al. 2002, Schreiner et al. 2009, Feller 2013) and trust (e.g.

Bucklin and Sengupta 1993, Mjoen and Tallman 1997, Parkhe 1993, Yan and Gray 1994, Judge and Dooley 2006).

Formal IP protection mechanisms define certain rights on the underlying IP. These rights can refer to universal ownership rights that bind everybody, such as patents, protected designs, copyrights, and trademarks. Alternatively mechanisms exist that bind only a limited number of actors. This is the case in particular for formal contracts between a given number of parties. Both mechanisms have in common that they define a formal right that can be defended or enforced in court. While this is a great advantage, it is commonly agreed that formal mechanisms are severely restricted because they offer only probabilistic protection. In the case of patents this stems from e.g. conflicting patent rights by others or uncertainty about litigation outcomes (Lemley and Shapiro, 2005). For the case of contracts it results from the unpredictability of future events and the indescribability of the underlying asset (Kloyer and Scholderer 2012, Joskow 1987, Williamson 1985).

In particular, the literature on relational mechanisms has therefore suggested that the relational mechanisms are both cheaper and more effective than formal mechanisms because they can eradicate the sources of opportunism rather than working on its symptoms with highly incomplete formal measures (Gulati 1995, Gulati and Singh 1998, Uzzi 1997). We have already argued that this view might be problematic because of the problem of ambiguity. We will elaborate this line of reasoning further here.

There are at least two theoretical arguments, which explain why relational mechanisms might not always be more effective than formal mechanisms. Formal protection mechanisms require the underlying knowledge assets to be spelt out, based on which a codified document (a patent, a contract,...) is created. This document may be a rough and sometimes simplistic description of the knowledge asset, but in light of great ambiguity it will facilitate the identification of the underlying knowledge assets. First, this has advantages for existing IP which are brought into the partnership, because it allows for a clearer attribution to each partner helping to organize and clarify the relations that would otherwise remain unspecified (Merges 1995). Second, it has advantages for the distribution of the IP to be generated in the partnerships. We have already argued that relational mechanisms are not very effective in cases of output ambiguity. Under these conditions formal contracts are often very effective because they can be made contingent on more easily observable proxy outputs. If these observable measures are sufficiently correlat-

ed to the intended goal – in the context of innovation partnerships this would be the generation of some knowledge asset – formal contracts may have a distinct advantage over relational mechanisms (Carson et al. 2006). We extend this argument to patents, trademarks, copyrights, and registered designs. In particular, the ambiguity associated with innovation partnerships will often make it difficult to identify the knowledge assets preexisting in or resulting from a partnership. Nonetheless, the associated formal IP is clearly identifiable. In that respect contracts can reduce the ambiguity problem by being made contingent on observable proxy goals, while other IPR (patents, brands, designs) may serve as appropriate proxy goals.

H2: Firms in innovation partnerships that make use of universal ownership rights reduce their hazard of experiencing IP infringement.

H3: Firms in innovation partnerships that make use of formal contracts reduce their hazard of experiencing IP infringement.

It is often agreed that formal protection mechanisms do not eradicate the sources of opportunism. They just increase its costs by creating a threat of legal punishment. But not all such assets qualify for formal protection, often due to tacitness. A characterizing feature of innovation partnering is, however, that it allows external partners to access highly tacit elements of the knowledge, which will often remain unprotected because they simply cannot be spelt out to the degree that is required for formal protection. Thus, we would expect that partners redirect acts of opportunistic infringement towards unprotected IP. This strategy has been referred to as outlearning (Khanna et al. 1998, Park and Ungson 2001, Kapmeier 2008). Furthermore, it might be the case that the mere existence of formally unprotected IP might send the signal to the partner that this IP is free to use, exacerbating the infringement risk.

H4: For firms in innovation partnerships the overall increase in the risk of IP infringement is primarily due to the increase in the risk of legal IP infringement.

3 Data and methodology

3.1 The data set

The data used to test our hypotheses is taken from the Mannheim Innovation Panel (MIP). The MIP is an annual survey of innovation activities of German enterprises. The MIP is the German contribution to the bi-annual Community Innovation Surveys (CIS) of the European Commission and fully complies with the methodological standards of the CIS. The MIP is based on a stratified random sample of enterprises located in Germany with 5 or more employees that have their main economic activity in mining, manufacturing, other industry, wholesale trade, transportation and storage, information and communication services, financial and insurance activities, and other business-oriented services. It has been used in a variety of management and economic analyses of innovation-related questions. More details on the MIP can be found in Peters and Rammer (2013).

In this paper we make use of the 2008 survey with reference year 2007 covering 6,110 firms in total. A major design objective of the CIS surveys is the representativeness of the whole economy. This is achieved in two ways. First, with a few exceptions (e.g. agriculture, facility management services), it covers all major sectors from manufacturing and services. Second, firms are sampled according to sector, size, and regional groups in order to reflect the population as closely as possible. Furthermore, Germany is the only country in the EU which conducts an extensive non-response analysis. This analysis shows that the sample of the participants is in all major innovation-related variables quite representative (with a slight overrepresentation of innovative firms). This implies that the overall participation biases are limited.

While we did not restrict the overall sample in any way, due to item-non-response additional drop-out occurs, so that the observations in the final regressions hover around 1,900. This drop out is primarily triggered by the innovation collaboration variables, which is often not answered by non-innovating firms. While it would therefore not seem unreasonable to exclude non-innovators immediately, a closer look at the data set reveals that about 1,000 firms, so roughly a sixth, report that they have not introduced a process or product innovation in the last three years but were part of an innovation partnership during that period. Such a restriction would therefore unduly exclude such firms from the analysis.

The survey is particularly well suited to answer the questions raised in the survey because in 2008 it had special sections on innovation partnering and infringement of IP.

3.2 Construction of variables and estimation methodology

The following discussion explains the model specification and the variables used. A summary can be found in Table 1.

H1 states that IP infringement becomes more likely when the firm is engaged in innovation partnerships. The survey has information on different types of IP, in particular technological inventions, products, brands & names, and designs. We estimate the influence of innovation partnering separating these types throughout the paper.

For innovation partnerships firms were separately asked to rate the importance of their involvement in innovation-related collaborations with client firms, client consumers, material suppliers, service suppliers, competitors, or public research institutions ranging from non-existing (0) to very important during the last three years. Out of these items we created a construct as a compound measure of both the number of different partners and the depth of the relationship. The reasoning relates to the risk of experiencing infringement, which should be an increasing function of both the depth of innovation partnering (more in-depth collaborations lead to disclosure and also more tacit knowledge) and the number of innovation partnerships (a higher number of ongoing collaboration multiplies risk of having to do with an opportunistic partner). While the available data allows for the measurement of the importance of collaboration (rated on a Likert-scale) there is no exact information on the absolute number of collaborative projects. The only information that is available is the number of different types of innovation partners. This can be thought of as a rough proxy for the number of projects. We therefore construct a variable that we call intensity of innovation collaboration by adding the importance variable (ranging from 0 to 2) for each type of innovation partner. A very similar strategy has been followed by Laursen and Salter (2006) who measure the related concept of a company's openness to external information by the breadth and depth of the use of external sources. They measured the breadth by the number of different types of information sources, where the types are largely the same that are used in this paper. The depth was measured using a Likert scale. We test the reliability of the innovation partnership intensity construct (as a compound measure of intensity and breadth) by the Cronbach's Alpha coefficients. This is 0.78, which is well above the minimum recommended threshold of 0.65 as concerns the validity of the scale.[3]

In H2 we suggest that firms that use universal ownership rights are less likely to experience IP infringement in innovation partnerships. The key variable here is the interaction between the partnership intensity and a protection measure. Concerning the latter there is information on whether firms used patents, technological designs, non-technological designs, trademarks, and copyrights. Here we create a construct by adding these different types. Theoretically this is jus-

[3] Separating breadth and depth did not lead to qualitatively differing results in the regressions.

tified by the findings in the literature dealing with the appropriation of returns from innovation, which consistently argues that firms successfully appropriating the returns combine different instruments, or in other words create a broad protection wall around their IP (Neuhäusler 2012; for the special case of the chemical industry compare Arora 1997). Thus the ability to prevent IP infringement is not necessarily related to the use of an isolated protection mechanism but to their combination. The Cronbach's alpha for the protection breadth measure was 0.74.

In H3 we hypothesize that formal contracts reduce the risk of IP infringement. There is information on whether contracts were used for the specific types of innovation partners. For example if a firm indicated collaboration with at least one supplier it was asked whether these relationships were at least sometimes governed by contracts. Since logically a contract may only affect that relationship to which it applies, we split up the partnership variable into the different types of collaboration partners and create interactions between the contract and the partnership variable for each type of partner separately.

H4 states that IP infringement in partnerships is likely to be legal in nature, it uses again the partnership intensity as the main explaining variable and a dummy of the illegality of the IP infringement as explained.

Concerning estimation techniques all models relating to H1-H3 were estimated using Probit models because the dependent variables (infringement yes/no separated by type of infringement) are dummy variables. In H4 additional estimation complexity emerges, because the dependent variable is only observable for firms that experienced IPR infringement at all. Otherwise the variable indicating the legality of the infringement is logically undefined. Ignoring this selection issue would imply endogenous sample selection. Thus a two-step Heckman model has to be estimated, where in a first step the overall infringement probability is explained and in a second step it is determined whether this infringement was illegal or not.

In all regressions we control for a set of potential confounders. These include the number of employees and its square to account for the size, the export intensity to control for exposition to outside markets usually increases the risk of infringement. Furthermore, we use R&D intensity as well as a share of new-to-firm products as a measure of the attractiveness of infringement for others. We include a variable indicating whether the company belongs to a group of indicators that is a rough proxy of relational capabilities which is more likely in firms that are used to maintaining external relationships. Finally, we include a set of used formal protection mechanisms in order to account for the ease of infringement and six sector dummies based on the OECD tech-level classification. This classifies firms into high-tech manufacturing, medium-high-tech manufacturing, medium-low-tech manufacturing, low-tech manufacturing, as well as knowledge-intensive services and other services.

4 Results

In Table 1 we present the descriptive statistics of the variables used in the following analyses, where the second row contains further information on the construction of the variables.

We see from the table that IP infringement appears to be a relevant phenomenon for a larger proportion of the firms. The lowest risk occurs for copying brands and names with a hazard of about 7.1% during the period between 2005 and 2007. It is 8.4% for copying designs and 8.9% for the infringement of technical inventions. The most important category is the copying of products with 10.8%.

Innovation partnering is reported on a 3-point-Likert scale, where the most common innovation partners were client firms. Only 30.1% answered that they had no partnerships at all. At 61.1% it was twice as high for consumers. Both for service and material suppliers 40.4% reported no innovation partnerships, while it was 53.0% for competitors as well as about 52.4% for public research organizations.

Table 1: Descriptive statistics

Variable	Scale	Obs	Mean	Std. Dev.	Min	Max
Infringement: Technical inventions	Dummy (yes=1)	5231	0.0893	0.2852	0.0000	1.0000
Infringement: Copying of products	Dummy (yes=1)	5214	0.1087	0.3114	0.0000	1.0000
Infringement: Copying of brands and names	Dummy (yes=1)	5203	0.0705	0.2561	0.0000	1.0000
Infringement: Copying of designs	Dummy (yes=1)	5209	0.0835	0.2767	0.0000	1.0000
Partnership with client firms	3-point-Likert (no to very important)	4754	1.3406	0.9116	0.0000	2.0000
Partnership with consumers	3-point-Likert (no to very important)	4323	0.6796	0.8944	0.0000	2.0000
Partnership with suppliers	3-point-Likert (no to very important)	4259	1.0780	0.8287	0.0000	2.0000
Partnership with competitors	3-point-Likert (no to very important)	4365	0.7320	0.8494	0.0000	2.0000
Partnership with public research institutions	3-point-Likert (no to very important)	4501	0.7956	0.8959	0.0000	2.0000
Innovation partnering intensity	Sum of preceding collaboration types	3966	5.0966	3.6852	0.0000	12.0000
Company used patents	Dummy (yes=1)	5067	0.2579	0.4375	0.0000	1.0000
Company used technological desings	Dummy (yes=1)	4837	0.2016	0.4012	0.0000	1.0000
Company used non-technological designs	Dummy (yes=1)	4581	0.0760	0.2650	0.0000	1.0000
Company used trademarks	Dummy (yes=1)	4932	0.2788	0.4485	0.0000	1.0000
Company used copyrights	Dummy (yes=1)	4631	0.1395	0.3465	0.0000	1.0000
Protection breadth	Sum of preceding IPR protection types	4430	0.6700	1.1898	0.0000	5.0000
Contracts used with client firms	Dummy (yes=1)	6110	0.3237	0.4679	0.0000	1.0000
Contracts used with client consumers	Dummy (yes=1)	6110	0.0928	0.2902	0.0000	1.0000
Contracts used with material suppliers	Dummy (yes=1)	6110	0.2288	0.4201	0.0000	1.0000
Contracts used with service suppliers	Dummy (yes=1)	6110	0.2748	0.4464	0.0000	1.0000
Contracts used with competitors	Dummy (yes=1)	6110	0.0972	0.2963	0.0000	1.0000
Contracts used with public research organizations	Dummy (yes=1)	6110	0.2093	0.4069	0.0000	1.0000
Market novelties introduced	Dummy (yes=1)	4754	0.2204	0.4146	0.0000	1.0000
#Employees	Positive count	6110	681.9430	8390.5100	0.0000	400000.0000
Exports per turnover	Positive real	4989	0.1627	0.2493	0.0000	1.0000
R&D exp. per turnover	Dummy (yes=1)	5531	0.0235	0.1105	0.0000	3.0048
Company located in Eastern Germany	Dummy (yes=1)	6110	0.3208	0.4668	0.0000	1.0000
Company part of group	Dummy (yes=1)	5985	0.3272	0.4692	0.0000	1.0000
High-tech manuf.	Dummy (yes=1)	6110	0.0755	0.2641	0.0000	1.0000
Medium-high-tech manuf.	Dummy (yes=1)	6110	0.1319	0.3384	0.0000	1.0000
Medium-low-tech manuf.	Dummy (yes=1)	6110	0.1399	0.3469	0.0000	1.0000
Low-tech manuf.	Dummy (yes=1)	6110	0.2336	0.4231	0.0000	1.0000
Knowledge intensive services	Dummy (yes=1)	6110	0.2810	0.4495	0.0000	1.0000
Other services	Dummy (yes=1)	6110	0.1381	0.3451	0.0000	1.0000

We now turn to the hypotheses, where we start with H1 stating that innovation partnering increases the risk of IP infringement. The major result in Table 2 is that innovation partnering significantly increases the hazard of infringement of types of surveyed IP except for the use of

brands or names. Here the estimate is marginally insignificant. After computing the marginal effects the results indicate that the risk increase is not only significant but also substantial in size. As concerns technical inventions an increase from the lowest value in the partnering variable to its mean increases the risk of experiencing infringement of technical inventions by 2.4%. It is 4% for products and 1.3% for copyrights and designs.

Compared to the average infringement hazards which lie between 10.8% for products and 8.4% for copyrights and designs (see Table 1) these increases are substantial. In particular, for the copying of products the increase relative to the average hazard in the population amounts to 37% (=4/10.8 %), but even for the lowest category, copyrights and designs, the risk increase is still 16%.[4] It is not particularly surprising that the value is highest for the infringement of products and technical inventions because innovation partnerships give additional access to tacit knowledge related to the technical inventions and the production process that is not available to outsiders to the same degree. Brands/names and designs on the other hand should also be observable to firms operating on the markets at arm's length. Thus it is expected that infringement in innovation partnerships should increase more strongly when complex or tacit knowledge is concerned. In summary, we conclude that H1 is corroborated.

4 Note that these figures relate to the risk associated with an average interaction in innovation partnerships. For firms with extreme values on the partnership intensity the risk increase is substantially higher.

Table 2: Infringement and innovation partnerships (Probit regressions)

	(1) Infringement: Technical inventions	(2) Infringement: Copying of products	(3) Infringement: Copying of brands and names	(4) Infringement: Copying of designs
Partnership intensity	0.0774***	0.0768***	0.0342	0.0414**
	(3.57)	(4.48)	(1.63)	(2.00)
Market novelties introduced	0.5130***	0.5715***	0.1052	0.5033***
	(4.68)	(5.67)	(0.88)	(4.26)
#Employees	0.0000	0.0000	0.0000	-0.0001*
	(0.13)	(0.26)	(1.55)	(-1.75)
#Employees_sq	0.0000	0.0000	-0.0000	0.0000
	(0.27)	(0.26)	(-0.62)	(1.49)
Exports per turnover	0.5984***	0.3546*	0.4685**	1.0866***
	(2.99)	(1.86)	(2.13)	(5.06)
R&D exp. per turnover	0.2203	-0.1184	-0.8141	-3.0616**
	(0.46)	(-0.26)	(-0.98)	(-2.33)
Company located in Eastern Germany	-0.3464***	-0.1946*	-0.5471***	-0.3694***
	(-2.60)	(-1.84)	(-3.53)	(-2.67)
Company part of group	0.1126	-0.0274	-0.0810	-0.3381***
	(1.03)	(-0.28)	(-0.71)	(-2.79)
Company used patents	0.6024***	-0.0879	0.1053	-0.0319
	(4.54)	(-0.69)	(0.71)	(-0.22)
Company used technological designs	0.2968**	0.3043**	0.1891	0.2772*
	(2.24)	(2.40)	(1.32)	(1.91)
Company used non-technological designs	0.1754	0.0725	0.2625	0.7978***
	(1.10)	(0.47)	(1.63)	(5.15)
Company used trademarks	0.1155	0.5210***	0.8033***	0.4257***
	(0.97)	(4.92)	(6.39)	(3.40)
Company used copyrights	0.0282	-0.1911	0.2131	0.0744
	(0.21)	(-1.52)	(1.62)	(0.53)
Constant	-2.2066***	-2.0479***	-2.1274***	-2.3414***
	(-11.15)	(-12.59)	(-10.18)	(-10.43)
Sector dummies	YES	YES	YES	YES
Observations	1921	1915	1920	1922
Pseudo R^2	0.362	0.219	0.280	0.302
Chi-sq	444.3328	290.4684	274.6843	311.6797

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Since the risk of infringement in innovation partnerships is large as the preceding results showed, the question arises how firms can protect themselves. H2-H3 hypothesize that firms can reduce the infringement hazard by the use of universal ownership rights as well as the use of contracts to govern their innovation partnerships, where the central argument was that formal mechanisms are effective also in the light of output ambiguity.

If one of H2-H3 is true we would expect that the interaction term between partnering intensity and the respective formal protection is negative. We start our discussion with H2 where the role of universal ownership rights is analyzed through the protection breadth measure (compare Table 3). Indeed we find that the partnering intensity is as positive as before. It is noteworthy that the coefficient on brands and names is now significant as well, which suggests that infringement is likely to become more probable also in this case, at least when formal protection is accounted

for. The interaction term is in all cases negative as predicted, where for intuitiveness a graphical representation of the complementary probability of not experiencing infringement is given in Figure 1. However, the risk-reducing effects are only significant in the case of infringement of products and brands and names. This is an interesting observation because the protection breadth does not contribute much to preventing the infringement of technical inventions. This observation stays remarkably unaltered when using just patent variables instead of the protection breadth (not displayed), which conveys a significant ineffectiveness not only of universal ownership rights in general but also of patents in particular to protect technical inventions in innovation partnerships. This might result from the fact that universal ownership rights require a high degree of describability of the underlying knowledge assets, while technical inventions often build on considerable tacit components as well. In that respect patents might be too restricted to create an effective protection. An alternative explanation might be that patents are usually quite narrow in that they only protect a very specific technical solution to a problem. But when alternative solutions exist infringers might try to invent around them. In this case the lacking effectiveness of universal ownership rights in protecting technical inventions might be the result of infringers' switching to legal infringement. In any case, this result suggests that universal ownership rights reduce the risk of IP infringement, but there remains an issue with technical inventions, which might be due either to the failure to protect the tacit components or the narrow "protection radius".

Contracts might be more effective, which can be more flexibly adapted to the partners' needs. For example, contracts can always include clauses on the mutually accepted use of tacit knowledge and know-how. They may also prohibit obvious invent-around strategies, which is not possible through universal ownership rights. In line with that H3 hypothesizes that contracts can reduce the IP infringement risk. The results can be found in Table 4, where the interactions are constructed by types of partners because logically a contract will only reduce the infringement risk, if it applies to that particular type of partner. Indeed we find that contracts can help to reduce the risk of infringement in particular of technical inventions. This holds for client firms and suppliers (though not for competitors). There are also some risk reducing effects on designs and copyrights. No effects can be observed for products and brands and names. In that respect contracts can become very useful as they prove to be more effective in protecting technical inventions in innovation partnerships than formal protection mechanisms.

Table 3: The mitigating role of formal protection mechanisms (Probit regressions)

	(1) Infringement: Technical inventions	(2) Infringement: Copying of products	(3) Infringement: Copying of brands and names	(4) Infringement: Copying of designs
Partnership intensity	0.0898***	0.1016***	0.0781***	0.0472*
	(3.17)	(4.85)	(2.71)	(1.82)
Protection breadth	0.2455	0.4779***	0.3896**	0.3075*
	(1.31)	(3.23)	(2.36)	(1.86)
(Protection breadth)*(Partnership intensity)	-0.0082	-0.0226**	-0.0270**	-0.0042
	(-0.70)	(-2.21)	(-2.36)	(-0.38)
Market novelties introduced	0.5118***	0.5711***	0.1049	0.5019***
	(4.68)	(5.70)	(0.89)	(4.25)
#Employees	0.0000	0.0000	0.0000*	-0.0001*
	(0.22)	(0.53)	(1.76)	(-1.67)
#Employees_sq	0.0000	0.0000	-0.0000	0.0000
	(0.21)	(0.13)	(-0.73)	(1.43)
Exports per turnover	0.5903***	0.3335*	0.4400**	1.0778***
	(2.94)	(1.74)	(1.99)	(4.99)
R&D exp. per turnover	0.2150	-0.1258	-0.8379	-3.0667**
	(0.45)	(-0.27)	(-1.01)	(-2.33)
Company located in Eastern Germany	-0.3468***	-0.1918*	-0.5494***	-0.3692***
	(-2.60)	(-1.80)	(-3.52)	(-2.67)
Company part of group	0.1111	-0.0298	-0.0842	-0.3380***
	(1.02)	(-0.31)	(-0.73)	(-2.79)
Company used patents	0.4143**	-0.3964*	-0.0812	-0.3076
	(2.00)	(-1.90)	(-0.35)	(-1.30)
Company used technological designs	0.1158			
	(0.48)			
Company used trademarks	-0.0749	0.1816	0.5603***	0.1419
	(-0.36)	(1.00)	(2.70)	(0.67)
Company used copyrights	-0.1570	-0.4986***	0.0187	-0.2016
	(-0.71)	(-2.90)	(0.10)	(-1.03)
Company used non-technological designs		-0.2120	0.1085	0.5234**
		(-0.93)	(0.43)	(2.10)
Constant	-2.6612***	-2.1504***	-2.3360***	-2.3611***
	(-10.45)	(-12.40)	(-9.90)	(-10.21)
Sector dummies	YES	YES	YES	YES
Observations	1921	1915	1920	1922
Pseudo R^2	0.363	0.223	0.285	0.302
Chi-sq	444.8245	295.3066	280.3182	311.8213

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Probability of not experiencing infringement as a function of protection breadth (upper left: technical inventions, upper right: products, lower left: brands and names, lower left: brand and names, lower right: designs

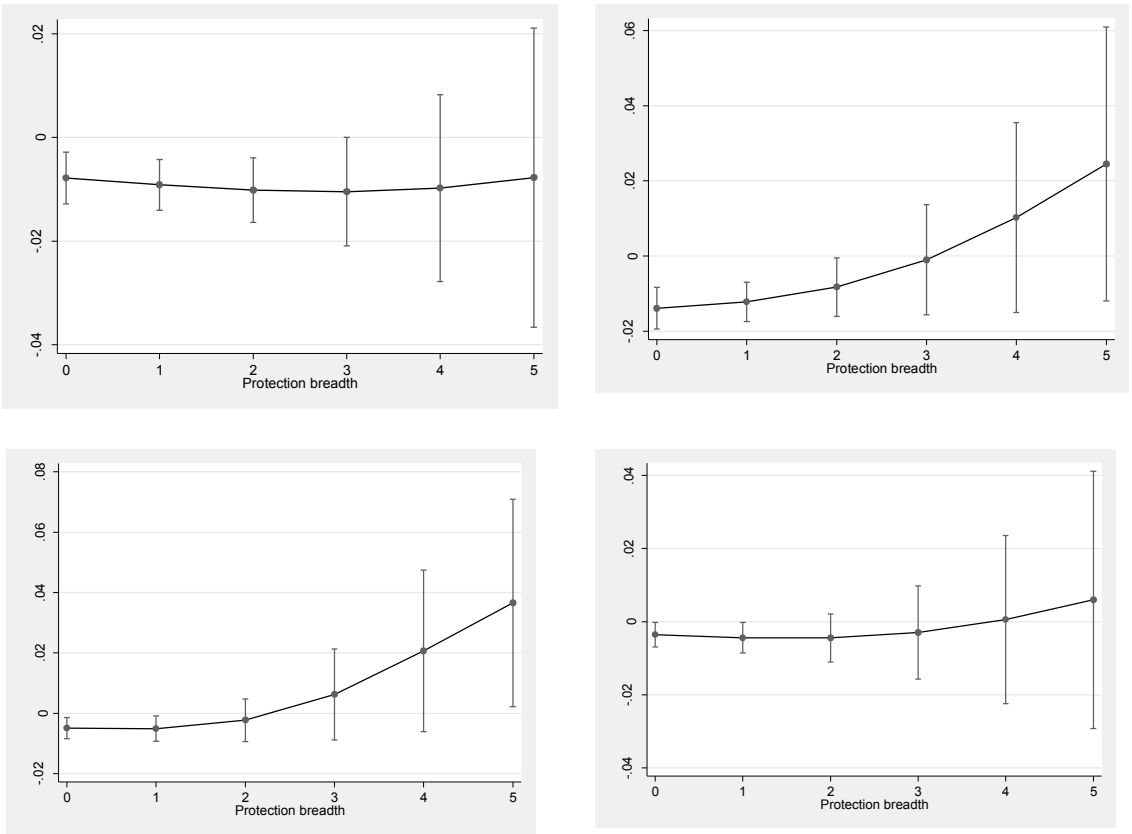

Table 4: The mitigating role of formal contracts (Probit regressions)

	(1) Infringement: Technical inventions	(2) Infringement: Copying of products	(3) Infringement: Copying of brands and names	(4) Infringement: Copying of designs
(Contracts used with client firms)*(Partnership with client firms)	-1.8530***	-0.4464	-0.1029	-1.1666**
	(-2.80)	(-1.10)	(-0.23)	(-2.05)
(Contracts used with consumers)*(Partnership with consumers)	0.6844	0.5953	0.0933	0.8752*
	(1.50)	(1.59)	(0.20)	(1.83)
(Contracts used with suppliers)*(Partnership with suppliers)	-0.3421***	-0.1523*	-0.1835*	-0.0874
	(-3.44)	(-1.76)	(-1.74)	(-0.82)
(Contracts used with competitors)*(Partnership with competitors)	0.2156	-0.1741	0.2460	0.1207
	(0.70)	(-0.63)	(0.79)	(0.32)
(Contracts used with universities)*(Partnership with public research organizations)	-0.2541	-0.0222	0.3917*	-0.5926**
	(-1.11)	(-0.11)	(1.72)	(-2.16)
Partnership with client firms	0.1494	0.0896	0.0803	-0.1125
	(1.00)	(0.74)	(0.55)	(-0.77)
Partnership with consumers	-0.0471	-0.0254	-0.0716	-0.0364
	(-0.56)	(-0.34)	(-0.77)	(-0.40)
Partnership with supplies	0.1814***	0.0919*	0.1844***	0.1236*
	(2.96)	(1.71)	(2.87)	(1.90)
Partnership with competitors	-0.0188	0.0893	-0.1100	0.0265
	(-0.26)	(1.43)	(-1.44)	(0.36)
Partnership with research organizations	0.1620*	0.0634	-0.0210	0.0489
	(1.80)	(0.86)	(-0.22)	(0.57)
Contracts used with client firms	2.0592***	0.6906*	0.2034	1.1787**
	(3.10)	(1.65)	(0.44)	(2.06)
Contracts used with consumers	-0.8617*	-0.6988*	0.1139	-0.8634
	(-1.72)	(-1.67)	(0.23)	(-1.64)
Contracts used with suppliers	0.6394***	0.3309*	0.3000	0.3682
	(2.70)	(1.65)	(1.21)	(1.47)
Contracts used with competitors	-0.2489	0.1426	-0.3116	-0.4602
	(-0.64)	(0.40)	(-0.77)	(-0.96)
Contracts used with public research organizations	0.4151	-0.0453	-0.4321	0.3816
	(1.51)	(-0.18)	(-1.55)	(1.19)
Market novelties introduced	0.4968***	0.5675***	0.0912	0.5606***
	(4.38)	(5.51)	(0.75)	(4.54)
#Employees	0.0000	0.0000	0.0000	-0.0001
	(0.35)	(0.78)	(1.64)	(-1.30)
#Employees_sq	0.0000	-0.0000	-0.0000	0.0000
	(0.12)	(-0.02)	(-0.69)	(1.17)
Exports per turnover	0.6104***	0.3435*	0.5177**	1.1423***
	(2.96)	(1.76)	(2.29)	(5.15)
R&D exp. per turnover	0.1418	-0.1073	-0.8871	-2.7717**
	(0.27)	(-0.22)	(-1.03)	(-2.11)
Company located in Eastern Germany	-0.3952***	-0.2032*	-0.5582***	-0.3625***
	(-2.87)	(-1.90)	(-3.52)	(-2.59)
Company part of group	0.0888	-0.0272	-0.0771	-0.3512***
	(0.78)	(-0.27)	(-0.65)	(-2.78)

Company used patents	0.5839***	-0.0890	0.0649	-0.0144
	(4.20)	(-0.68)	(0.43)	(-0.09)
Company used technological designs	0.2776**	0.2943**	0.1934	0.3127**
	(2.03)	(2.30)	(1.33)	(2.09)
Company used non-technological designs	0.2378	0.0993	0.2934*	0.7957***
	(1.44)	(0.64)	(1.76)	(4.96)
Company used trademarks	0.1514	0.5767***	0.8329***	0.4580***
	(1.24)	(5.37)	(6.53)	(3.55)
Company used copyrights	0.0147	-0.1823	0.2183	0.0983
	(0.11)	(-1.43)	(1.63)	(0.68)
Constant	-2.7749***	-2.0899***	-2.2241***	-2.1745***
	(-10.71)	(-12.34)	(-10.10)	(-9.72)
Sector dummies	YES	YES	YES	YES
Observations	1921	1915	1920	1922
Pseudo R^2	0.390	0.227	0.295	0.321
Chi-sq	478.3813	300.3908	289.5127	331.9611

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As our last hypothesis we investigate whether the infringement that usually occurs in the context of innovation partnerships is more likely to relate to formally protected or unprotected IP. This question is particularly important because usually a firm fails to protect all its IP formally. This may have several reasons. First, obtaining formal protection can be expensive leading firms not to protect all its IP. Second, firms may have forgotten about important knowledge assets. Third, some IP, in particular if tacit knowledge assets are involved, is simply excluded from formal protection legal grounds. This will always open up leeway for partner opportunism. We argued in H4 that partnering firms are more likely to infringe unprotected IP because they do not have to fear formal punishment. Additionally, they might also not consider it infringement because the IP is not sufficiently identified as a knowledge asset the partner considers essential to him.

We have run a Heckit sample selection model, where the selection variable is whether a firm has experienced infringement of the respective type of IP. We report only the second stage regression, which is of primary interest to us. The first stage regression basically repeats the results obtained in Table 2, i.e. innovation partnering increases infringement. The coefficients in the second stage regression of the Heckman model to be found in Table 5 can be interpreted as conditional. For example, when we find that the coefficient of innovation partnering is negative for the fact the experienced infringement was illegal, this means that given that firm has experienced infringement, it is less likely to be illegal (or more likely to be legal).[5]

[5] Note that the negative sign does not mean that the overall risk of illegal infringement is reduced. It has a conditional interpretation and means that given that a firm experienced infringement, legal infringement becomes more likely. It does not per se imply that illegal infringement becomes less likely in absolute terms. In particular, since the overall risk of infringement is increased (see Table 2) it may well be true that also illegal IP infringement becomes overall more likely. In that respect the coefficient says something about the distribution between legal and illegal infringement but not about the size of the overall infringement risk.

The results indicate that the shift towards legal infringement can only be observed for IPR related to technical inventions and the copying of brands and names. In the other cases the shares of legal or illegal infringement are not affected. We thus corroborate H4, but only for brands and names as well as technical inventions. These results offer an alternative explanation using missing effectiveness of universal ownership rights in protecting brands and in particular technical inventions. It does not need to be necessarily true that the respective protection mechanisms (e.g. patents) are too weak to create an effective protection. The result might simply be due to the effect that infringing firms seek to circumvent patents and other IP and shift their infringement activities to IP where they do not have to fear punishment. As concerns the specific case of patents this might be due to invent around strategies or to the infringement of tacit components.

Table 5: Illegal vs. legal infringement in innovation partnering (Heckman sample selection regressions)

	(1) Illegal IPR infringement: Technical inventions	(2) Illegal IPR infringement: Copying of products	(3) Illegal IPR infringement: Copying of brands and names	(4) Illegal IPR infringement: Copying of designs
Partnership intensity	-0.0388**	0.0009	-0.0339**	-0.0183
	(-2.50)	(0.07)	(-2.15)	(-0.85)
Market novelties introduced	-0.2990***	-0.1678*	0.0277	-0.1631
	(-3.68)	(-1.79)	(0.35)	(-0.97)
#Employees	0.0000	0.0000	-0.0000	-0.0000
	(0.10)	(1.41)	(-0.26)	(-0.25)
#Employees_sq	-0.0000	-0.0000	0.0000	0.0000
	(-0.14)	(-1.30)	(0.26)	(0.37)
Exports per turnover	-0.1217	0.0435	0.3121*	0.1299
	(-0.83)	(0.32)	(1.74)	(0.35)
R&D exp. per turnover	-0.2781	1.2316*	1.0646	-1.3882
	(-0.62)	(1.87)	(1.47)	(-0.89)
Company located in Eastern Germany	-0.0071	0.1330	-0.0959	0.1434
	(-0.07)	(1.60)	(-0.60)	(0.78)
Company part of group	-0.1207	0.0866	0.1918**	0.0826
	(-1.54)	(1.31)	(2.48)	(0.66)
Company used patents	0.2506**	0.1278	0.0879	-0.0811
	(2.39)	(1.57)	(0.79)	(-0.69)
Company used technological designs	0.0311	-0.1184	-0.0101	0.0398
	(0.34)	(-1.32)	(-0.09)	(0.29)
Company used non-technological designs	0.0199	0.2308***	0.0828	0.1308
	(0.19)	(2.77)	(0.74)	(0.48)
Company used trademarks	0.0266	0.1339	0.1683	0.1114
	(0.31)	(1.43)	(0.87)	(0.75)
Company used copyrights	-0.0477	0.1116	0.0027	0.0211
	(-0.52)	(1.40)	(0.03)	(0.19)
Constant	1.8714***	0.3835	0.5640	0.4401
	(8.17)	(1.03)	(0.84)	(0.39)
Observations	1908	1887	1905	1904
Uncens. Observations	174	182	121	128
Indep. eq. LR-test	13.63***	0.60	0.00	0.03

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5 Implications and conclusion

In this paper we have provided the first quantitative analysis of the link between innovation partnering and IP infringement showing that the associated risk increase is with up to 37% very large. This highlights that knowledge leakage is an empirically important threat in innovation partnerships, which is at odds with claims in the relational literature that trust, reputation, or relational capital would eliminate the sources of opportunism altogether. Two explanations are conceivable. First, relational mechanisms do not solve the ambiguity problem effectively (Carson et al. 2006). Second, without explicit attribution of pre-existing IP to the partners, conflict about these assets may become more likely. In this light our results suggest that the distribution of all IP should be as clear as possible. In that respect having established a high degree of trust might not be sufficient, when an agreed demarcation between the partners' and own IP has not been achieved. Overall, this implies that opportunism should not be discarded prematurely because relational mechanisms bring their own problems.

We further showed that firms can effectively reduce the infringement risk by employing formal protection mechanisms. However, not all of them are under all conditions equally effective. Universal ownership rights (brands, designs) were much more able to protect products and designs, while they did not contribute to a reduction of the infringement risk of technical inventions. Somewhat surprisingly, even patents failed to protect technical inventions from infringement in innovation partnerships. Contracts in contrast proved more effective in reducing the risk of infringement of technical inventions, but showed little effect against the infringement of products. So both universal ownership rights and contracts appear to have complementary strengths in protecting different kinds of IP. This may serve as an explanation for the observation that firms usually use a combination of protection mechanisms in practice (Neuhäusler et al. 2012).

While our emphasis of complementary strengths is an important first step in the analysis of the effectiveness of formal protection mechanisms it also hints at the need to work out central contingencies. To work out the case specificities and the central contingencies it might be useful to examine the specifics of the appropriability regime as discussed by Teece (1986). In particular, technological innovations are usually difficult to protect by patents when the degree of tacit knowledge is relatively high. While this is often the case – explaining also our finding of low weak patents – there are also instances like chemical formulae or simple mechanical inventions where patents might satisfactorily work. In these cases, the need to resort to contracts in order to protect the tacit components might not be as urgent. Furthermore, the power of patents depends on the existent of a dominant design, because invent-around will be easier when a dominant design has not yet been achieved so that there are a large number of alternative technological path-ways. Patents will then be weak and protection mechanisms like contracts, which have the power to restrict the infringers' behavior (e.g. forbid invent-around), could be more effective. In

contrast, when dominant designs exist, patents may be stronger. This suggests that the more fundamental and market-creating the purpose of an innovation partnership is, the weaker patents will be and therefore the greater is the need for contracts. Finally, Teece (1986) highlights that whether the results of innovation can be effectively protected also depends on the existence of complementary assets like distributions channels or marketing. In particular the latter is important in the context of our results because successful marketing will increase the strength of brands. Our result that brands are effective in protecting products will fundamentally depend on whether these brands are perceived to be strong by the customers. If this is not the case, registering a brand or a trademark will not necessarily yield the desired level of protection. This is particularly probable if the infringer's brands are seen as relatively stronger.

Thus the effective combination of different formal protection mechanisms is specific to each innovation partnership and requires a fundamental consideration of at least the degree of appropriability based on characteristics of the technology (tacit vs. codified knowledge), the phase of the technological cycle (existence of dominant designs), and the existence of complementary assets (amongst others strength of the brands). Although this paper has provided some foundational insights into how advantages and disadvantages of the different formal protection mechanisms play out on average, much more research is needed on how the above mentioned contingencies shape the specifics of a case.

Besides the implications for the combination of each of the formal protection mechanisms, our results also have bearings on how relational and formal protection mechanisms can be fruitfully combined. This context showed that formal protection mechanisms, although reducing infringement risks, are not a panacea for opportunism, as infringement activities were found to shift to legal domains. Because formal protection mechanisms operate on the symptoms of infringement, there is little hope that they prevent it altogether when they are incomplete. Instead, this suggests that research should analyze whether and how relational mechanisms and formal protection mechanisms can be fruitfully combined in their respective strengths, which calls for steps to integrate insights from the IPR literature and the relational literature.

One possible way to implement this integration can be based on the argument by Carson et al. (2006) that contracts can solve the ambiguity problem of relational mechanisms. In specific, if sanctioning in relational mechanisms is hard to trigger because of ambiguity, contracts may serve as proxies on which sanctioning is conditioned, because they define permissible behaviors. This argument is, however, not limited to contracts but also extends to the case of universal ownership rights. So for example instead of defining IP in terms of the unobservable knowledge assets, firms commonly will make attribution and distribution decisions with reference to the patents. If a patent is then infringed, this may not only lead to legal but also social sanctioning. This suggests a complementary relationship between formal and relational protection mechanisms. Such a perspective is particularly interesting, because some authors have proposed that

formal protection mechanisms will be increasingly crowded out by relational mechanisms in the course of the evolution of the partnership (Gulati 1995, Gulati and Singh 1998, Uzzi 1997). In contrast to that Ryall and Sampson (2009) and Poppo and Zenger (2002) find that during the partnership the use of both formal and relational mechanisms becomes more intense. This is much more in line with a complementary rather than a substitutive relationship.

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