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If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies

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ABSTRACT

This empirical study examines small firms' strategies for capturing returns to investments in innovation. We find that small firms' strategies are qualitatively different from those found in earlier studies of both small and large firms. Most of the small firms examined here find informal means of protection, such as speed to market or secrecy, more important than patenting. Only firms with university cooperation—typically R&D intensive and science-based small firms—were likely to identify patents as the most important method of appropriating innovation returns in their field. Thus, the strategic choice for most small firms is between secrecy and speed to market. Firms that cooperate in innovation with horizontal partners or significantly depend on vertical partners tend to prefer speed, whereas process innovators with modest R&D investments or few cooperative R&D activities display a preference for trade secrets. Indeed, cooperation activities greatly influence the choice of intellectual property strategy for small firms. Earlier research has emphasized patents and trade secrets as key strategies of appropriation, yet these strategies do not appear to be very beneficial for small firms engaged in cooperative innovation. These results raise policy questions regarding the functionality of the existing system of intellectual property rights.

1. Introduction

Innovators' capacity to benefit from their investments in knowledge creation is a central concern in innovation and technology policy. Firms' opportunities to protect the returns from their innovation activities—appropriability—have been identified as one of the key incentives for innovation (Levin et al., 1987), and as a justification for the intellectual property rights system itself (Gallini, 2002; Kultti et al., 2006). This study explores intellectual property (IP) strategies of small Finnish manufacturing and service firms. We find that patents, although usually emphasized in the study of IP protection, are not a very important mechanism for most small firms. Additionally, we find that few firms rely on trade secrets. Our novel finding is that most small firms, and particularly small firms that engage in cooperative innovation activities with external partners, emphasize speed to market as the most important protection mechanism. On this basis, we argue that small firms' IP strategies differ from those of larger firms, and because of the economic importance of innovation by small firms, intellectual property rights policies should be re-evaluated from the small-firm perspective.

This study is based on a diverse sample of small firms and a broad set of intellectual property protection mechanisms. We conduct a statistical analysis of small and innovative Finnish manufacturing and service firms that suggests that the importance of patenting depends on the firm's research orientation: firms cooperating with universities and firms with high R&D investments indicate patents are helpful for appropriation. In this regard, our results corroborate those of Gans et al. (2002) and Gans and Stern (2003). However, patenting firms are a rather small subset of the sample; roughly 12% of all firms and 19% of innovating firms in the sample have any patents, and these firms are concentrated in chemicals and R&D services.

Apart from research-oriented firms, a large majority of small firms do not view patents as the most important IP protection mechanism. Most firms rely on the informal strategies of secrecy and speed to market in protecting their innovation returns. We find consistent evidence that cooperation with external partners in innovation or other business activities has significant implications for the perceived benefits of different IP strategies. Small firms with significant vertical relationships (clients or suppliers that provide a third or more of the focal firm's business) or horizontal collaborative innovation arrangements are statistically significantly more likely than other firms to emphasize speed instead of secrecy in attempting to protect innovation returns, controlling for other firm and industry characteristics. We interpret this result in the light of

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small firms' limited bargaining power within external relationships. Small firms are likely to be dealing with partners larger than themselves, in which case they may be in a weak position to appropriate the intellectual outputs from joint work. Moreover, patenting may not be a useful strategy for the lack of resources to apply for and defend patents. In an intensive cooperation arrangement, secrecy might not work either, because external partners may be able to learn and pass on the technological secrets of the focal small firm.

The rest of the paper is organized as follows. We first discuss earlier studies on IP strategies and inter-firm cooperation in order to derive hypotheses about small firms' strategies to protect innovation returns. We then introduce the Finnish survey dataset and carry out the empirical analyses. The last section discusses the implications of our empirical results for research and policy.

2. Literature on appropriability and empirical hypotheses

Mechanisms to appropriate intellectual assets include formal methods such as utility patents and other forms of intellectual property rights, and informal methods such as secrecy, lead time, moving quickly down the learning curve, and sales and service efforts (e.g., Harabi, 1995; Tether and Massini, 2007). Much of the research on appropriability has focused on firms' activities regarding patenting and trade secrets (e.g., Kultti et al., 2006). Other informal mechanisms such as lead time (or speed to market) and learning have received less explicit attention.

Small firms have been characterized as the "fruit flies of innovation" (De Jong and Marsili, 2006); they are a quickly evolving and important sub-population of innovating organizations. Innovative entry to existing industries can change the competitive dynamics and overtake established, high performing incumbents (Audretsch, 1995; Christensen and Rosenbloom, 1995; Henderson and Clark, 1990). The competitive fringe is viewed as crucial in providing a constant innovative challenge to incumbents (Scherer, 1980; Gilbert and Newbery, 1982). However, there has been little research focusing on IP strategies of small firms. In one of the few existing large-sample studies, Arundel (2001) examines the relative importance of secrecy and patenting by firm size. He finds that small firms perceive patents as less efficient than trade secrets in protecting the "competitiveness of innovations" (see also Kitching and Blackburn, 1998).

Other studies suggest that although small firms more often need to enforce their patents through litigation (Lanjouw and Schankerman, 2004) and may be more vulnerable to preliminary injunctions (Lanjouw and Schankerman, 2001), patents are very beneficial for science-based or venture capital-financed small firms (Gans et al., 2002; Gans and Stern, 2003). In particular, Gans et al. (2002) find that patenting is likely to be observed when high-technology firms commercialize their innovations through licensing. The market for technology depends on well-defined intellectual property rights. However, to our knowledge, research has not simultaneously considered the relative benefits of speed to market, secrecy, and patents for small firms in a variety of different types of industries.

Research on all types of firms suggests that the nature of innovative activity along with firm and industry characteristics influence firms' choices of how to protect intellectual property. Although firms generally rank patents as inferior to other mechanisms (Cohen et al., 2000; Harabi, 1995), Arundel (2001) finds that large firms are more likely than small firms to benefit from patents rather than secrecy. Small firms often lack the resources necessary to legally defend their patents (Cohen et al., 2000), and furthermore, their patent enforcement costs tend to be higher because they rarely benefit from cross-licensing arrangements or reputations for aggressive IP protection strategies, which both help avoiding costly lawsuits (Lanjouw and Schankerman, 2001).

Involvement in inter-firm cooperation has also been found to influence the choice of IP protection mechanism. Firms that engage in cooperative arrangements with other firms benefit from specialized knowledge of their partners and interactive learning that takes place in a joint R&D project (Sobrero and Roberts, 2002). It can be argued that R&D cooperation with other firms increases the value of patenting, because patents help to define partners' rights to emerging intellectual property explicitly, and, moreover, firms can use their portfolio of patents as bargaining chips in negotiations with partners over cross-licensing and the ownership of the joint R&D output (Cohen et al., 2002). Arundel (2001) finds weakly significant evidence regarding the preference for patenting over secrecy by firms that cooperate in R&D activities.

For smaller firms, however, patenting may not be an option, because of the aforementioned resource constraints. As a result, larger cooperation partners may use their bargaining power to claim ownership of intellectual assets that results from joint innovation. Indeed, Cassiman and Veugelers (2002) suggest that cooperation with suppliers or customers is negatively associated with the effectiveness of all appropriation mechanisms. Considering that small firms typically have weaker bargaining abilities, we expect that small firms that have cooperative arrangements do not find the use of patents or trade secrets particularly advantageous.

Additionally, product innovations are more likely to be patented than process innovations (Harabi, 1995). A process innovation is typically more effectively kept within a firm and protected with trade secrets, while a product must be released to the market at large and may therefore be subject to reverse engineering. For process innovations, the legal protection offered by patents may not be worth the disclosure of information required by a patent application.

Industry-specific characteristics have also been found to influence firms' choices of IP strategies. For example, according to Brouwer and Kleinknecht (1999), firms' propensity to patent is higher in high-technology industries than in other industries. Also, Arundel and Kabla (1998) find that the effectiveness of patents in preventing imitation varies across industries. Further, Cohen et al. (2000) divide industries into those producing discrete or complex products and argue that firms patent for different reasons in these two types of industries. Discrete products, such as food or chemicals, tend to have few components, and innovations in these areas are simpler to protect by patents. In contrast, complex products, for example, electronics products or machinery, typically require many different components in their construction. Cohen et al. (2000) argue that an innovation in these areas often requires licensing or other arrangements to gain access to technologies from other firms, making commercialization of an innovation more challenging. Therefore, patenting is pursued in complex-product industries for strategically different reasons than in discrete-product industries.

Small firms generally do not have extensive patent portfolios to cross-license, which makes operating in a complex-product environment difficult. This may induce small complex-product firms to steer away from technologies and products where strategic patenting is necessary. Thus, a small firm in a complex-product industry may instead decide to focus on product areas where they can effectively compete by getting to market quickly or by providing superior marketing and complementary services in lieu of patents. Moreover, it is often much easier to invent around technologies in the engineering-based complex-product industries than it is in discrete-product industries. These factors reduce the incentive to patent and may lead complex-product firms to rely on time to market or secrecy instead.

Another distinction relevant in the dataset used here is between firms in service and manufacturing industries. Recent studies have argued that because of the intangibility of services, modes of inno-

Table 1
Survey studies of appropriability.

Survey	Citation	Targeted representation	Firm size	Key result
Yale	Levin et al. (1987)	Publicly traded R&D performing manufacturing firms in the United States	Biased toward large firms	Non-patenting methods are typically more important, but substantial inter-industry variation exists.
PACE	Arundel and Kabla (1998)	Largest European R&D performing firms	Large firms	Patenting propensity increases with firm size.
CIS/Eurostat	Arundel (2001)	Manufacturing and service firms in 7 European countries	All sizes; biased toward innovative firms	Secrecy relatively more important for small firms than for large firms. R&D cooperation increases the value of patents.
Carnegie-Mellon	Cohen et al. (2000)	R&D performing manufacturing firms in the United States	All sizes	Secrecy has become relatively more important. Reasons for patenting vary across industries.
ETLA (the current dataset)	Hyytinen and Pajarinen (2003); current study	Technology-intensive small firms in Finland	Small	Involvement in inter-firm cooperation increases the importance of speed to market for small firms.

vation and appropriability conditions differ markedly between service and manufacturing activities (Miles and Boden, 2000). For example, Tether (2005) suggests that firms in service sectors innovate differently: they more often have the goal of organizational innovation rather than product innovation, and rely more on employees' skills and external cooperation rather than formal R&D. Similarly, Leiponen (2005) finds that skills and external knowledge sourcing rather than in-house R&D drive innovation in knowledge-intensive business service firms. The importance of external knowledge sourcing and cooperation suggests that service firms' knowledge boundaries may be even more porous than those of manufacturing firms. This may have implications for service firms' strategies of appropriation. Indeed, Tether and Massini (2007) show that British service firms are overall less likely than manufacturing firms to use formal methods of appropriation such as patents, registered designs, trademarks and copyright. Service firms also use fewer informal methods such as secrecy, lead time, complexity of design and confidentiality agreements. However, these authors also find that there is substantial variation in utilization of methods of appropriation within the service sector. Taken together, these prior studies suggest that controlling for differences in determinants of IP strategies between and within the two main sectors is important in conducting research and evaluating strategies.

Table 1 summarizes the key results from earlier major survey-based studies of firms' methods of appropriation. The current survey dataset is also included. This comparison is intended to highlight the unique contribution of this study: the novelty here is to illuminate the relationship between R&D cooperation and small firms' methods of appropriation.

3. The dataset of small knowledge-intensive Finnish firms

In the empirical analyses to follow, we utilize data from a survey of small Finnish firms.[1] Finland is a small open economy and highly integrated with other European economies through its membership in the European Union (EU). The Finnish system of intellectual property rights is largely aligned with those in other EU countries because of the European Patent Convention, although to our knowledge there is no comparative scholarship that would provide direct evidence about this. The Finnish innovation system is also for the most part similar to those in other EU member countries. Compared to other OECD countries, the most unique features are the extent and high quality of the public education system (e.g., OECD, 2006), high investments in R&D and their concentration in electronics, particularly in telecommunication equipment, and the large number of researchers per total employment (OECD, 2008). Moreover, the government plays a relatively active role in funding R&D. Through the National Technology Agency TEKES, the Finnish government funds research related to national technology programs by firms, universities, and non-profit research institutes, and often this funding is more easily obtained for some type of collaborative research projects to promote spillovers in the economy. Indeed, R&D cooperation is more common in Finland than in most other OECD countries. Nevertheless, the share of cooperating firms in Finland is about the same as in Denmark (Leiponen and Drejer, 2007) and only slightly higher than that in the United Kingdom (Tether, 2002). Overall, there is little reason to expect the relationship between firms' innovation activities and IP strategies to substantially differ between Finland and other EU countries.

Four explicit IP strategies are identified in the survey: patents, secrecy, speed to market, and complementary production, products, or services. Firms were asked to identify which of these mechanisms is the most important one for protecting innovations in their field. As in the Yale and Carnegie-Mellon surveys (see Table 1), respondents were asked to provide their views about their field of business rather than their firms' specific strategies. The supplementary survey information about IP strategies actually used by the respondents shows that most firms use more than one strategy, and, hence, the survey instrument forced them to choose the dominant mechanism. This may incorporate some measurement error if, in reality, multiple methods are perceived as equally important. The advantage of this formulation of the survey question is that it generates a statement about the relative importance of the different methods rather than an absolute assessment of their effectiveness. This alleviates concerns of inter-respondent differences in the interpretation of subjective scales (see Arundel, 2001).

We seek to explain firms' responses of the most important methods of IP protection through regression analyses. Explanatory firm-level variables include firm size, R&D expenditures, exports, and type of innovation (product or process). We control for industry differences using either two-digit NACE[2] industry dummies or technology sector dummies. The main explanatory variables of interest include binary variables representing firms' engagement in cooperative innovation activities with competitors, with other firms

[1] Firms that have fewer than 100 employees, of which a large majority have fewer than 50 employees.

[2] Nomenclature Actuariel de la Communauté Européenne, the European classification of economic activities that largely corresponds to the North American Industrial Classification System.

(clients, suppliers, or other commercial organizations), or with universities. The survey also asks whether firms generate more than one-third of their procurement or sales from a single supplier or a single client, respectively. Many small firms are characterized by these kinds of dedicated relationships with (usually larger) suppliers and clients.

The survey data were collected by ETLA, the Research Institute of the Finnish Economy, and are described in detail by Hyytinen and Pajarinen (2002, 2003, 2005). Hyytinen and Toivanen (2005) utilized the same database in their study of small innovating firms' financial constraints. The first survey was implemented in 2002 and sampled 2600 small and medium-sized Finnish firms in all economic sectors except agriculture, finance, and real estate. 936 firms responded, resulting in a response rate of 36 percent. The initial purpose of the survey was to describe the financial characteristics of small and medium-sized Finnish firms, with an emphasis on high-technology firms. The survey design, therefore, oversampled firms in high technology, medium high technology, and information-intensive service sectors relative to the entire population of small Finnish firms. These categories account for about 60 percent of the sample. The 2002 survey questionnaire is largely based on the Survey of Small Business Finances by the Federal Reserve Board (2003; see also Berger and Udell, 1998). The second survey dataset, collected in 2003, targeted the respondents from the previous survey, resulting in 830 responses. The main purpose of the second survey was to investigate the consumption of publicly provided business services by small and medium-sized Finnish firms. The resulting overall response rate for the combined sample was 32 percent.

Because of the sampling approach, firms in our dataset are more R&D intensive, growth- and export-oriented, and more likely to hold patents and other intellectual property rights than the general population of small businesses in Finland (Hyytinen and Pajarinen, 2002, p. 8). The key benefits of using this source of data include the time lags between the explanatory and dependent variables. Most explanatory variables (number of employees, research and development expenditures, relationships with major clients and suppliers, innovation activities, technology classifications, and export orientation) were observed one year earlier than the dependent variables. Only R&D cooperation variables are concurrent with the dependent variables. Unfortunately, questions about R&D cooperation were not included in the first survey. Additionally, the dataset provides exceptionally detailed information about methods of appropriation and about firms' vertical and R&D cooperation relationships.[3]

Descriptions of all variables are shown in Table 2 and summary statistics in Table 3. Firm size is measured by the natural logarithm of the number of employees in the firm. On average, firms in the estimation sample have 13 employees, ranging from 1 to 97 employees. The natural logarithm of R&D, research and development expenditures in thousands of Euros, is used to control for the extent of the firm's innovation activity. Types of innovation were determined through binary questions asking whether firms had introduced, in the previous three years, a process innovation or a product innovation. Export is another binary variable indicating whether the firm reported exporting any products. To assess the role of vertical business relationships, firms were asked whether they had a client that

[3] For example, Community Innovation Surveys might be a reasonable data alternative for this type of a study, but the current dataset has clear advantages over CIS. First, the Finnish CIS undersamples small firms, which makes it difficult to draw inference separately about this subset of firms. Second, the four-year lags between CIS waves are too long to provide informative lagged variables. Finally, CIS does not include questions about vertical business relationships, which is a very important strategic aspect for small firms.

Table 2
Variable descriptions.

Appropriation mechanisms	Description
Patent	Patents are the most important appropriation mechanism
Secrecy	Secrecy is the most important appropriation mechanism
Speed	Speed to market is the most important appropriation mechanism
Other appro	Complementary production, products, services or other means are the most important appropriation mechanism
Continuous variables	
Log(employees)	Natural logarithm of the number of employees
Log(R&D)	Natural logarithm of R&D expenditures (Euros)
Binary variables	
Export	1 if firm has any exports, 0 otherwise
Product innovation	1 if firm has introduced a product innovation in the previous three years, 0 otherwise
Process innovation	1 if firm has introduced a process innovation in the previous three years, 0 otherwise
Horizontal cooperation	1 if firm has cooperated in innovation with firms in the same industry, 0 otherwise
Vertical cooperation	1 if firm has cooperated in innovation with suppliers, clients, or consultants, 0 otherwise
University cooperation	1 if firm has cooperated in innovation with universities or research institutes, 0 otherwise
Vertical dependence	1 if firm has either a client with share of sales or a supplier with share of procurement greater than 33%, 0 otherwise
Discrete tech	Discrete technology products, 1 if firms has NACE < 2900, 0 otherwise
High tech	1 if firm's industry is classified as high tech by the OECD, 0 otherwise (pharmaceuticals; instruments; radio, tv, communication eqpt; computers)
Medium tech	1 if firm's industry is classified as medium high tech by the OECD, 0 otherwise (electrical machinery; vehicles & transport eqpt; chemicals; machinery)
Low-tech services	1 if firm's industry is utilities, transport services, or wholesale trade, 0 otherwise
Knowledge-intensive business services	1 if firm provides knowledge-intensive business services (R&D services; other business services), 0 otherwise
Telecom and software	1 if firm provides telecommunication or software services, 0 otherwise

Table 3
Summary statistics ($N = 504$) for continuous variables.

Variable	Mean	St. Dev.	Min	Max
Employees	13.0397	15.2740	1	97
R&D expenditures (1000 Euros)	391.290	981.404	0	6600

Summary statistics ($N = 504$) for binary variables.

Variable	% of sample
Patent	24.60
Secrecy	15.48
Speed	41.87
Product innovation	46.43
Process innovation	31.15
Export	41.87
Vertical dependence	50.60
Horizontal cooperation	29.76
Vertical cooperation	38.10
University cooperation	22.02
Discrete tech	24.01
High tech	11.51
Medium tech	28.57
Knowledge-intensive business services	9.52
Telecom and software	16.87
Low-tech services	21.83

accounted for more than one third of their sales and whether they had a supplier that accounted for more than one third of their procurement. We combined these answers to create the binary variable vertical dependence that equals one if the firm identifies either a client or a supplier that accounts for more than one third of its business and zero otherwise. About half of the firms in the sample have such relationships.[4]

Another aspect of external dependence is represented by cooperative innovation activities. The binary variable horizontal cooperation indicates whether the firm affirmatively answered the question about cooperation with firms in the same industry, while vertical cooperation indicates if the firm affirmatively answered the question about cooperation with clients, suppliers, or other firms in other industries. Similarly, university cooperation is a binary variable for firms cooperating in R&D with universities. These measures are taken from the second (2003) survey. Almost 40 percent of the sampled firms engaged in vertical R&D cooperation, 30 percent in horizontal R&D cooperation, and 20 percent in cooperation with universities. Thus, it is rather common for innovative small firms to cooperate in innovation—about half of the firms cooperate with at least one type of a partner.

To control for industry differences, we formed industry dummies based on two-digit NACE classes. Alternatively, technology class definitions can be used to assess what types of industries are more likely to emphasize the different appropriation methods. Based on OECD definitions (see Hatzichronoglou, 1997), we created dummies for high-technology (high tech) and medium-high-technology (Medium tech) manufacturing industries. To account for the substantial diversity within the service sector, separate binary indicators were also defined for low-technology services (low-tech services: utilities, transportation, wholesale trade), knowledge-intensive business services (R&D services, consulting services), and telecommunications and software services (telecom and software), whereas the reference group includes low-technology manufacturing industries. Additionally, discrete is an indicator for firms whose products fit the definition of discrete products from Cohen et al. (2000).[5] Machine, electronics, and transportation vehicle industries involve complex technologies, whereas other manufacturing industries deal with discrete technologies. Finally, we test for differences between service firms and manufacturing firms.

The dependent variables come from the 2003 survey, where firms were asked which strategy was the most important when protecting innovations in their field of business: patents, secrecy, complementary production or services, speed (being faster to market than competitors), or other strategies. The variables patent, secrecy, and speed are thus mutually exclusive binary variables.

42 percent of the sample indicated speed to market is the most important means to protect innovations, 25 percent of the sample indicates patents, and 15 percent indicates secrecy. Additionally, four percent of the firms indicate that complementary products or services are the most important way to protect innovations, and the remaining firms were undecided. These shares remain approximately the same if we only consider firms that actually introduced product or process innovations in the preceding three years. The majority of the sampled small firms thus find that informal means are the most effective in protecting their innovations.[6]

As supplementary information, a set of binary variables from the first survey indicate which IP strategies firms had used in the previous three years. Complementary products are the most commonly used strategy for innovating firms (70% of firms used this strategy in the preceding three-year period), followed by speed to market (64%), and secrecy (62%). Patents were used by 16 percent of firms, the lowest of all (although only 12% of the sampled firms had any patents at the time of study—the remaining firms may have been in the process of applying for patents). When these actually utilized IP strategies are included as explanatory variables in probit models explaining respondents' choices of the most important IP strategies, utilization of patents highly significantly and positively explains the choice of patents as the most important method, and, similarly, utilization of secrecy and speed to market highly significantly explain the choices of secrecy and speed to market strategies, respectively. Most firms thus appear to utilize—and benefit from—multiple methods of appropriation, but for the purposes of the empirical analyses carried out here, we focus on the information regarding firms' choices of the most important method, which highly correlate with actual usage of the method.

To keep our focus on small firms, we remove a handful of firms that had more than 100 employees. However, although this cutoff is frequently used (e.g., European Commission, 2003b), it is somewhat artificial, and some other sources define small firms as fewer than 50 employees (e.g., OECD, 2009) or fewer than 500 employees (e.g., Federal Reserve Board, 2003). We tested whether the results were affected by the definition utilized.

After combining the two surveys, the sample consists of 504 observations of firms that participated in both surveys and had information about R&D expenditures and the dependent variables, which were the chief sources of item non-response. The cooperation variables were also a source of item non-response. We assume that the firms that did not respond to the cooperation questions but did respond to the rest of the questionnaire did not have cooperative R&D arrangements. However, we also discuss robustness results for the subset that provided explicit information about cooperation. Table A1 in the Appendix A shows basic descriptive statistics for all 696 available observations, and Table 3 displays summary statistics for the estimation sample of 504 firms. Table A2 in the Appendix A displays pairwise correlations for these 504 firms.

The summary statistics show few biases in the estimation sample relative to all available observations. The estimation sample of 504 observations is very slightly biased toward larger and more R&D intensive firms. The mean of R&D expenditures is 391,000 Euros for the estimation sample compared to 381,000 Euros for the full set of observations. The robustness sample with cooperation information of 288 firms shows more significant differences. The mean of R&D expenditures for this sample is 613,000 Euros. Firms spending on R&D were thus more likely to complete the cooperation questions; these firms are also more likely to engage in R&D cooperation. The sample with cooperation information also contains a greater share of exporters (52% vs. 42%), a greater share of product innovators (65% vs. 46%), and a greater share of process innovators (39% vs. 31%) than the sample of all available observations. In summary, the main sample of 504 firms is relatively unbiased compared to the whole survey, but the sample of 288 observations with explicit information about R&D cooperation is more significantly biased toward innovation- and export-intensive firms. However, we believe that this bias is not a serious problem since the latter sample is used for robustness testing. Moreover, we are interested in the relationships between firms' innovation and cooperation activities and their strategies to protect the returns from these activities. A focus on innovation-oriented firms is then quite natural and welcome. It is nevertheless useful to keep in mind that some of the results only apply to a set of randomly

[4] A supplementary analysis separated vertical dependence into its client and supplier parts, but this did not provide any more empirical insight. The combined variable better represents the underlying firm characteristic of interest: dependence on a vertical business partner.

[5] These are firms in the NACE classes 150 through 289.

[6] It should be noted that this survey did not specifically ask about the use of copyright, which may be relevant in particular for firms in software services. Copyright, trade names, and trademarks were all included in the "other" category.

Table 4
Industry groups and the importance of appropriation methods by industry ($N = 504$).

NACE	Description	Firms	Patent	Secrecy	Speed
15–16	Food, beverages, tobacco	11	0.27	0.09	0.45
17–19	Textiles, apparel, leather	12	0.17	0.33	0.25
20–21	Wood, pulp, paper	20	0.15	0.05	0.55
22	Printing and publishing	15	0.13	0.13	0.33
24–25	Chemicals, rubber, plastics	25	0.44	0.32	0.16
26–27	Non-metallic minerals and products; basic metals	10	0.10	0.20	0.50
28	Fabricated metal products	28	0.36	0.21	0.32
29	Machinery and equipment	72	0.31	0.18	0.32
30–31	Office machinery and computers; other electrical machinery	37	0.19	0.11	0.57
32	Radio, TV, communication equipment	46	0.20	0.24	0.48
33	Medical, precision, optical instruments, watches, clocks	38	0.39	0.08	0.42
34–35	Transport equipment	8	0.38	0.00	0.63
36–37	Furniture, other manufacturing, recycling	6	0.17	0.00	0.33
40, 60, 63	Electricity, gas, steam, water; land transport, pipelines; other transport activities	10	0.20	0.00	0.60
51	Wholesale trade	33	0.24	0.00	0.55
64	Post and telecommunications	9	0.22	0.11	0.33
72	Computer and related activities	76	0.12	0.17	0.57
73	Research and development	14	0.47	0.20	0.07
74	Other business activities	33	0.21	0.18	0.27
Total		504	0.25	0.15	0.42

Notes: Vehicle wholesale trade, retail trade, hospitality, real estate, employment/recruitment, and cleaning service firms were dropped.

sampled innovation-oriented and high-technology-based small firms.

4. Empirical analyses of the choice of intellectual property protection strategy

We model the discrete choice of the most important mechanism for IP protection as a function of the number of employees, R&D expenditures, inter-firm cooperation, exports, and industry or technology class:

$$Pr(\text{IP Mechanism}) = f(\text{Employees, Export, R\&D, Cooperation, Technology}) + \varepsilon;$$

where ε is an iid random variable. The estimation method is multinomial logistic maximum likelihood. The multinomial logit method takes into account the probabilities of other alternatives when estimating the effects of the explanatory factors on any one choice. This better corresponds to the respondents' choice situation than considering each of the alternatives in isolation. We first estimated single-equation probit models for each of the possible choices of IP protection methods, and found that the marginal effects obtained were very similar to the marginal effects for the multinomial logit. Therefore we only report the multinomial logit results.

We checked the independence of irrelevant alternatives assumption (IIA) with the Hausman test to make sure the model is correctly specified. When IIA holds, the coefficients for the remaining alternatives are stable even when one of the alternative protection methods is excluded from the multinomial logit model. A different concern is that because patents are utilized by relatively few firms, they may not be a relevant alternative for some firms. However, industry-level summary statistics in Table 4 demonstrate that there are firms that identify patents as the most important method in all industries. Patenting is thus not an activity applicable only to firms in certain types of industries. In contrast, secrecy is not reported as the most important method by any firms in eight industries.[7] Regardless, because secrecy is a low-cost method of appropriation, we are confident about the relevance of secrecy as an appropriation alternative for all firms.

Because the survey dataset contains many missing observations of the R&D cooperation variables, we first estimate the choice of most important protection method without the cooperation variables, and then add these variables in the second specification. The multinomial logit results are presented in Tables 5 and 7, and the marginal effects of each model in Tables 6 and 8, respectively. The reference alternative is secrecy or other methods. Other methods primarily include the provision of complementary products or services.

The first set of estimation results in Table 5 suggest that firms emphasizing patents or speed to market are significantly more heavily engaged in R&D than firms relying on secrecy. In fact, R&D investments are the only factor that statistically significantly distinguishes firms emphasizing patents from those emphasizing secrecy. In addition to their strong engagement in R&D, firms that reported speed to market as the most important method are significantly more likely to be engaged in intensive vertical business relationships and horizontal R&D cooperation than are firms that prefer secrecy.

In contrast to the raw estimation coefficients, which represent a comparison against the reference case, the marginal effects reported in Table 6 indicate that the probability of choosing patents as the most important appropriation method is most strongly correlated with R&D cooperation with universities. In contrast, firms that engage in vertical dependence relationships but not in process innovation or university cooperation tend to prefer the speed to market method. Horizontal R&D cooperation is only a marginally significant factor for firms with a preference for speed to market. Finally, aligned with the raw estimation results, the probability of preferring secrecy decreases with R&D and horizontal R&D cooperation.

Tables 7 and 8 display results from models that include technology classes instead of industry classes. These two specifications explain slightly less of the total variance, as indicated by the log likelihood and the pseudo R^2, but they provide some additional insight into the types of industries where firms chose each of the three main alternatives as the most important one. In particular, firms in service industries, overall, are slightly less likely to choose patents than are firms in manufacturing industries, but there is significant variation in the importance of patents within the service

[7] These include transport equipment; furniture and other manufacturing; recycling; electricity, gas, steam, water; land transport, and pipelines; other transport activities; and wholesale trade. These eight industries are grouped into four industry groups in Table 4 because of small numbers of observations.

Table 5
Multinomial logit models of reported importance of appropriation mechanisms.

Variable	(1)				(2)			
	Patents		Speed		Patents		Speed	
	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Constant	−1.007**	0.469	−0.789*	0.420	−1.122**	0.476	−0.948**	0.429
Log(employees)	−0.014	0.128	0.056	0.111	−0.013	0.131	0.079	0.116
Log(R&D)	0.084***	0.027	0.064***	0.024	0.072**	0.028	0.057**	0.025
Export	0.381	0.287	0.301	0.259	0.237	0.298	0.275	0.265
Product innovation	−0.263	0.299	0.139	0.266	−0.397	0.313	0.032	0.275
Process innovation	0.086	0.297	−0.477*	0.270	0.072	0.300	−0.522*	0.273
Vertical dependence	0.085	0.259	0.462**	0.228	0.097	0.261	0.465**	0.231
Horizontal cooperation					0.385	0.335	0.639**	0.301
Vertical cooperation					0.106	0.322	0.229	0.286
University cooperation					0.525	0.369	−0.346	0.351
Food, beverages, tobacco	0.509	0.943	0.702	0.841	0.617	0.953	0.702	0.859
Textiles, apparel, leather	−0.931	0.931	−0.816	0.821	−0.651	0.937	−0.582	0.821
Wood, pulp, paper	−0.270	0.838	0.624	0.646	−0.155	0.844	0.748	0.650
Printing and publishing	−0.904	0.909	−0.166	0.690	−0.732	0.913	−0.196	0.700
Chemicals, rubber, plastics	0.091	0.627	−1.184*	0.719	0.100	0.643	−0.972	0.726
Non-metallic minerals and metals	−1.019	1.214	0.344	0.794	−0.781	1.214	0.480	0.796
Fabricated metal products	0.471	0.648	−0.007	0.624	0.548	0.655	0.076	0.628
Machinery and equipment	0.088	0.522	−0.239	0.484	0.221	0.529	−0.168	0.490
Office machinery, computers etc.	−0.056	0.670	0.574	0.561	−0.050	0.678	0.649	0.565
Radio, TV, communication eqpt etc.	−0.439	0.609	0.134	0.518	−0.353	0.616	0.164	0.524
Medical instruments etc.	0.964	0.626	0.654	0.597	1.030	0.632	0.677	0.604
Furniture etc.	−0.056	1.247	0.051	1.013	−0.017	1.256	0.216	1.021
Electricity etc.					0.843	1.110	1.479	0.928
Wholesale trade	0.617	0.623	1.095**	0.545	0.716	0.675	1.027	0.593
Post and telecommunications	−0.545	0.991	−0.420	0.881	−0.345	0.996	−0.426	0.892
Computer and related activities	−0.876	0.586	0.357	0.472	−0.913	0.592	0.353	0.477
Research and development	0.185	0.697	−2.072*	1.141	−0.086	0.717	−2.079*	1.154
Log likelihood	−496.80				−490.15			
Pseudo R^2	0.084				0.096			

Specifications include two-digit industry dummies, except for transportation equipment, the dummy for which cannot be identified (too few observations and limited variation). The reference industry is "other business activities," which includes engineering and management consulting and advertising, among other business services. The base alternative is secrecy and other appro combined.

* Significance at 90% level of confidence.

** Significance at 95% level of confidence.

*** Significance at 99% level of confidence.

sector. The results for the second specification indicate that software and telecommunication services are particularly unlikely to find patents to be the most important. On the other hand, "low-technology" services (energy utilities, transport services, wholesale trade etc.) are likely to benefit from speed to market, whereas knowledge-intensive business services (R&D services and various technical, management, and advertising consultancies) tend to rely on secrecy.

Contrary to expectations we find no statistically significant differences between small manufacturing firms in discrete and complex-product industries. For small Finnish manufacturing firms, strategic patenting considerations do not directly appear to influence appropriation strategies. A possible explanation is that the Finnish legal environment is less litigious than that of North America where most studies of strategic patenting have been conducted. As a result, discrete and complex-product suppliers are about equally likely to appreciate each method of protection. Alternatively, strategic patenting may be less relevant for small firms than for large firms.

In a last set of specifications (not reported in the tables), we further examined the differences between the service and manufacturing sectors by estimating separate coefficients for R&D, vertical dependence, and the three R&D cooperation variables for service firms. These results are available from the authors on request. In general, the effects of R&D investments, business cooperation, or R&D cooperation on firms' preferences for protection methods do not differ between service and manufacturing firms. The only marginally significant exception is the horizontal R&D cooperation variable. An interaction term between the service dummy and the horizontal cooperation dummy has a positive coefficient that is significant at the 89% level. Thus, to some degree, the result that horizontal R&D cooperation is associated with a preference for speed to market over patents or secrecy may be a result specific to service firms. Upon closer inspection, this result appears to be influenced by the strong tendency of horizontally cooperating telecom and software service providers to prefer speed to market. When an interaction between the telecom and software service dummy and the horizontal cooperation dummy is included, the coefficient of horizontal cooperation alone is no longer significant, although it remains positive. This suggests that a relatively small subset of service firms may be driving the result on horizontal cooperation. However, the result that vertical dependence strengthens the preference for speed to market is not different for service and manufacturing firms, which reinforces our interpretation of these findings.

All models were supported by the Hausman IIA test, implying that the coefficients for each alternative are independent of the other alternatives. Also, in the current analyses, the 19 firms choosing complementary products or services as the most important mechanism were combined with the reference group of firms that chose secrecy as the most important method. Dropping these observations had little effect on the magnitude or significance of the coefficients. We also examined dropping all observations for firms that did not report having innovated in the first survey. The main results remain positive and statistically significant. Finally, we tested whether the results were influenced by the definition of small firms as those with fewer than 100 employees. 481 firms out of the 504 in the main sample have fewer than 50 employees,

Table 6
Marginal effects.

Variable	Secrecy		Patents		Speed	
	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Log(employees)	−0.012	0.023	−0.011	0.021	0.023	0.024
Log(R&D)	−0.014***	0.005	0.007	0.005	0.007	0.005
Export	−0.056	0.053	0.016	0.047	0.040	0.056
Product innovation	0.028	0.056	−0.074	0.049	0.046	0.059
Process innovation	0.066	0.056	0.066	0.050	−0.131**	0.055
Vertical dependence	−0.074	0.047	−0.029	0.041	0.102**	0.049
Horizontal cooperation	−0.118**	0.056	0.002	0.051	0.116*	0.062
Vertical cooperation	−0.041	0.058	−0.004	0.051	0.044	0.061
University cooperation	−0.004	0.070	0.141**	0.066	−0.137**	0.066
Food, beverages, tobacco	−0.131	0.132	0.033	0.159	0.098	0.181
Textiles, apparel, leather	0.147	0.177	−0.060	0.132	−0.086	0.174
Wood, pulp, paper	−0.102	0.113	−0.097	0.096	0.199	0.137
Printing and publishing	0.085	0.155	−0.096	0.109	0.011	0.162
Chemicals, rubber, plastics	0.108	0.140	0.109	0.131	−0.217	0.115
Non-metallic minerals and metals	−0.036	0.161	−0.144	0.104	0.180	0.179
Fabricated metal products	−0.056	0.113	0.103	0.127	−0.047	0.130
Machinery and equipment	0.004	0.097	0.060	0.096	−0.065	0.103
Office machinery, computers etc.	−0.092	0.102	−0.074	0.085	0.166	0.119
Radio, TV, communication eqpt etc.	0.000	0.108	−0.073	0.081	0.073	0.116
Medical instruments etc.	−0.159*	0.088	0.124	0.116	0.035	0.122
Furniture etc.	−0.029	0.194	−0.025	0.204	0.054	0.245
Electricity etc.	−0.189**	0.076	0.000	0.097	0.189*	0.113
Wholesale trade	0.095	0.192	−0.022	0.155	−0.073	0.186
Post and telecommunications	−0.002	0.099	−0.163***	0.059	0.165	0.106
Computer and related activities	0.221	0.167	0.125	0.156	−0.346***	0.096
Research and development						

The reference industry is “other business activities,” which includes engineering and management consulting and advertising, among other business services.
* Significance at 90% level of confidence.
** Significance at 95% level of confidence.
*** Significance at 99% level of confidence.

Table 7
Multinomial logit models of reported importance of appropriation methods including industry types.

Variable	(1)				(2)			
	Patents		Speed		Patents		Speed	
	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Constant	−0.728*	0.372	−0.608*	0.333	−0.917**	0.405	−0.599*	0.353
Log(employees)	−0.041	0.122	0.060	0.107	−0.045	0.125	0.009	0.109
Log(R&D)	0.059**	0.026	0.052**	0.022	0.073***	0.027	0.055**	0.024
Export	0.310	0.285	0.331	0.252	0.177	0.292	0.277	0.257
Product innovation	−0.412	0.300	0.014	0.263	−0.381	0.304	0.014	0.267
Process innovation	0.073	0.290	−0.569**	0.265	0.052	0.292	−0.581**	0.266
Vertical dependence	0.094	0.251	0.526**	0.220	0.097	0.253	0.494**	0.223
Horizontal cooperation	0.429	0.323	0.694**	0.290	0.453	0.326	0.728**	0.294
Vertical cooperation	0.021	0.313	0.163	0.277	0.090	0.315	0.185	0.280
University cooperation	0.545	0.349	−0.479	0.330	0.599*	0.356	−0.344	0.336
Discrete	−0.214	0.309	−0.255	0.282				
Service	−0.504*	0.301	−0.020	0.256				
High tech					−0.213	0.443	−0.050	0.390
Medium tech					0.124	0.332	0.015	0.300
Low-tech service					0.606	0.533	0.908**	0.458
Knowledge-intensive business services					−0.396	0.458	−0.975**	0.461
Telecom and software					−1.034**	0.463	0.078	0.355
Log likelihood	−513.68				−504.09			
Pseudo R^2	0.053				0.0704			

In the first specification, the reference group is complex manufacturing. In the second specification, the reference group is low-technology manufacturing. The base alternative is secrecy and other appro combined.
* Significance at 90% level of confidence.
** Significance at 95% level of confidence.
*** Significance at 99% level of confidence.

and 392 firms have fewer than 20 employees. Using a size cutoff of 50 employees in the estimation did not change any of the statistically significant results. Using a cutoff of 20 employees also confirmed most of the significant results, except that the coefficients of all the R&D cooperation variables became less significant and obtained slightly smaller marginal effects. In contrast, the vertical dependence variable retained its significance and magnitude in both samples.

5. Discussion and conclusion

This study argues that the factors associated with choices for the most important appropriation methods differ between small

Table 8
Marginal effects.

Variable	Secrecy		Patents		Speed	
	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Log(employees)	0.002	0.022	−0.009	0.020	0.007	0.023
Log(R&D)	−0.014***	0.005	0.008*	0.004	0.006	0.005
Export	−0.053	0.051	0.004	0.046	0.049	0.055
Product innovation	0.028	0.054	−0.071	0.047	0.042	0.057
Process innovation	0.075	0.055	0.068	0.049	−0.144***	0.053
Vertical dependence	−0.077*	0.045	−0.033	0.040	0.110**	0.047
Horizontal cooperation	−0.133**	0.054	0.003	0.050	0.130**	0.060
Vertical cooperation	−0.033	0.056	−0.003	0.049	0.036	0.059
University cooperation	−0.013	0.066	0.158**	0.064	−0.146**	0.062
High tech	0.024	0.081	−0.033	0.065	0.009	0.083
Medium tech	−0.012	0.060	0.021	0.054	−0.009	0.064
Low-tech service	−0.155**	0.070	0.003	0.080	0.153*	0.092
Knowledge-intensive business services	0.174*	0.095	0.010	0.079	−0.185**	0.084
Telecom and software	0.054	0.077	−0.161***	0.048	0.107	0.079

* Significance at 90% level of confidence.
** Significance at 95% level of confidence.
*** Significance at 99% level of confidence.

and large firms. Overall, in protecting their innovation returns, small firms tend to rely on speed to market rather than patents or secrecy. This is particularly true of R&D intensive small firms that are engaged in horizontal R&D cooperation or have vertical business dependencies (a single client or a single supplier provides at least a third of its business). We interpret this statistical association through the assertions that, first, small firms do not have the resources to obtain and defend patents, and second, trade secrets are difficult to maintain in close cooperative relationships.

Patents are perceived as particularly beneficial by highly R&D intensive firms and firms that cooperate in R&D with universities. The preference for patenting has relatively little to do with the industrial or technological environment, except that service firms are somewhat less likely than manufacturing firms to prefer patents. Few small firms perceive secrecy as the most important method of protection. Secrecy is found beneficial mainly by firms that invest little in R&D and do not engage in external cooperative relationships.

This study contributes to a growing literature on the functioning and effectiveness of the intellectual property rights system, and particularly, the role of small innovating firms therein. We find that innovating and cooperating small firms are less able to benefit from the current patent system than are their larger counterparts. Whereas earlier studies have focused on the relatively special subset of venture capital-backed small firms (Gans et al., 2002), this study examines a broader sample of small firms that includes firms from both the manufacturing and service sectors. Additionally, our results differ from those studies focused on larger firms in which patenting and R&D cooperation are found to be positively associated (Arundel, 2001). We therefore argue that innovative small firms that have close cooperative arrangements may be at a disadvantage in protecting their innovation returns.

The institutional setup for protecting innovation returns appears not to be scale neutral, and if policymakers want to ensure a level playing field for all innovators, critical assessment of the system may be necessary. Our understanding of the opportunities and strategies applied to intellectual property rights protection has to be revised when we focus specifically on small firms. The patent system is generally viewed as the cornerstone of socially beneficial incentives for innovative activity (and its partial disclosure), yet patents appear to work rather poorly from the perspective of small firms. Few small, innovative firms rely on patents, and even fewer firms rely on trade secrets, and as a result, most innovative small firms simply accelerate their investments to enter the markets quickly.

Innovative SMEs are believed to be the key factor behind sustained growth of the economy and employment (e.g., European Commission, 2001, 2003a,b, 2006; see also Audretsch, 2004). How could intellectual property right policies encourage small firms to invest in innovation? Some possible solutions include modification of the European patent system to enable access for innovators with few resources to apply for and defend patents. For example, patenting fees could be defined on a sliding scale depending on the applicant's resources,[8] and governments could provide or procure services for small innovators to obtain, defend, and enforce their patents, for example, in the context of national R&D programs. Lanjouw and Schankerman (2001) have also suggested insurance arrangements against the risk of litigation for small firms. Other possible mechanisms include a European Patent Defense Union for SMEs as suggested by Kingston (2000). The results of our study can be interpreted to lend support to calls to modify institutions or create new institutions to facilitate small firms' access to patent protections.

Another result from this study, perhaps more surprising than unequal access to patent protections, is that most small innovating firms do not perceive secrecy as a very effective appropriation strategy. One of the key factors behind this result is cooperative innovation. Many innovative SMEs engage in cooperative R&D. Secrecy is difficult to maintain in joint projects, and patents are too expensive to originate and defend for many small firms. Thus, the only recourse is to appropriate returns to innovation by quick market launch.

The relationship between inter-firm cooperation and protection through speed to market has additional implications for innovation policy. In many European countries, Finland included, R&D subsidies are more readily available to firms with collaborative innovation projects, with the idea that collaboration channels spillovers from publicly funded R&D to the rest of the economy. Whenever publicly subsidized R&D projects require close cooperative relationships, small firms are likely to attempt to speed up market launch rather than rely on secrecy or patents for protection. National innovation programs may thus indirectly influence the IP protection strategies of participating firms, depending on what kinds of mandates for inter-firm cooperation are specified. Our results suggest that technology programs involving horizontal R&D cooperation may lead to faster commercialization than those with vertical or university R&D cooperation.

[8] This feature already exists in the United States.

Whereas this study is based on a sample from a small European economy, many of its results are in line with earlier studies that utilized differently focused samples. This increases our confidence in the generalizability of the results. The novelty of this research is its explicit focus on small firms, representing both service and manufacturing sectors, and their external dependencies. The results highlight the recourse by small firms to other means than patents or secrecy for appropriating the returns on their innovation investments—in the majority of cases speed to market. We conclude that the emphasis on patents in debates concerning the institutional environment for innovation may be misplaced. A broader appreciation for how intellectual property protection is pursued by firms in various populations will enrich the debate. More theoretical and empirical research is needed on how dependence on speed to market—the key mechanism of IP protection for small firms influences market structure, R&D investment, patterns of collaboration, and innovation outcomes.

Finally, although our study benefited from time lags of the main explanatory variables thus reducing the simultaneity bias, except in the case of the cooperative innovation variables, future research could carry out these kinds of analyses in a longitudinal setting to reduce possible endogeneity biases. For example, R&D cooperation and the main method of appropriation could both be determined by firms' unobserved characteristics, such as the nature of firms' capabilities or their competitive strategies. If this is the case, then the coefficient of R&D cooperation would be inflated. This could be better assessed with longitudinal data or a research design involving a natural experiment, for example, a policy change related to R&D cooperation. Unobserved heterogeneity would be easier to control in these types of research designs.

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Appendix A.

See Tables A1 and A2.

Table A1
Summary statistics for all available data (N = 696).

Variable	Mean	St. Dev.	Min	Max
R&D expenditures (thousand Euros)	381.566	923.978	0	6600
Employees	12.606	15.024	1	97
Export	0.412	0.493	0	1
Age	15.769	14.751	1	109
Product innovation	0.466	0.499	0	1
Process innovation	0.318	0.466	0	1
Vertical dependence	0.516	0.500	0	1
Discrete tech	0.230	0.421	0	1
High tech	0.132	0.339	0	1
Medium tech	0.277	0.448	0	1
Low-tech services	0.085	0.279	0	1
Knowledge-intensive business services	0.092	0.289	0	1
Telecom and software	0.170	0.375	0	1
Patent	0.178	0.383	0	1
Secrecy	0.112	0.316	0	1
Speed	0.303	0.460	0	1

Table A2
Correlations (N = 504).

	Patent	Secrecy	Speed	Log (employees)	Log(R&D)	Export
Patent	1					
Secrecy	−0.2444*	1				
Speed	−0.4848*	−0.3631*	1			
Log(employees)	0.0472	0.0248	0.0042	1		
Log(R&D)	0.1087	−0.0625	0.0837	0.2678*	1	
Export	0.0942	−0.1074	0.0462	0.2834*	0.3885*	1
Product innovation	0.0132	−0.0354	0.0487	0.036	0.4247*	0.2261*
Process innovation	0.0833	0.0675	−0.0758	0.1573*	0.2927*	0.0979
Vertical Dependence	−0.0437	0.0059	0.0985	−0.0965	−0.087	−0.1267*
Horizontal cooperation	0.0614	−0.1106	0.0985	−0.0378	0.3250*	0.1777*
Vertical cooperation	0.0641	−0.0533	0.0548	0.0548	0.3496*	0.2536*
University cooperation	0.1633*	−0.0553	−0.0531	0.1479*	0.3301*	0.2963*

	Product innovation	Process innovation	Vertical dependence	Horizontal cooperation	Vertical cooperation
Process innovation	0.3789*	1			
Vertical dependence	−0.0588	0.0048	1		
Horizontal cooperation	0.3077*	0.1431*	−0.0338	1	
Vertical cooperation	0.3757*	0.1958*	−0.0093	0.4366*	1
University cooperation	0.2541*	0.1078	−0.0686	0.3871*	0.4507*

* Significance at the 99% level of confidence.

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