Can’t block, must run: Small firms and appropriability

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Abstract

This empirical study examines small firms’ strategies towards appropriating the returns to their investments in innovation and finds that they are qualitatively different from those found in earlier studies of more generally representative samples of firms. First, few of the smallest firms appear to benefit from patenting. Even within this sample of small firms, only the largest firms were likely to identify patents as the most important method of appropriating innovation returns. Thus, the strategic choice for most small firms is between secrecy and speed to market. The smallest firms and those in low technology or complex product industries tend to prefer speed, while small investments in R&D, discrete product technologies, and affiliation with higher technology industries explain preference for trade secrets. These results raise policy questions regarding the functioning of the existing systems of intellectual property rights when key policy goals include innovation by and growth of small firms. Furthermore, innovation policies that mandate collaboration are likely to significantly influence firms’ appropriability strategies.

KEY WORDS SMEs, intellectual property rights, innovation, collaboration

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1 Introduction

Innovators' ability to benefit from their investments is a central concern in innovation and technology policy. Appropriability—firms' capability to protect and appropriate the returns from their innovation activities—has been identified as one of the key incentives for innovation (Levin et al., 1987) and it is thus the justification for the intellectual property rights system itself (Gallini, 2002; Kultti, Takalo, & Toikka, 2006). This study explores the special nature of appropriability strategies of small firms. We argue that some of the usual mechanisms emphasized in the study of appropriability are not feasible for most small firms and that, consequently, their appropriability strategies are different from larger firms. In particular, the role of patents in protecting innovation returns is much less pronounced for most small firms, and relatively few firms find trade secrets valuable either.

Small firms have been characterized as the "fruit flies of innovation" (de Jong & Marsili, 2006); they are a very dynamic and interesting subset of innovating organizations. In particular, innovative entry to existing industries can change the competitive dynamics and overtake even highly established and successful incumbents (Audretsch, 1995; Christensen & Rosenbloom, 1995; Henderson & Clark, 1990). Arguably, the competitive fringe is very important in providing the constant innovative challenge to incumbents (Scherer, 1980; Gilbert & Newbery, 1982). However, it hasn't been studied in detail how small firms protect their returns to innovation investments. It has generally been assumed that small firms rely on similar strategies as larger firms do (although see Arundel, 2001; Kitching & Blackburn, 1998). However, this study demonstrates that, most likely for lack of resources and for specific vertical dependencies, small firms' appropriability strategies are qualitatively different from those of more established innovators.

In a statistical analysis of a sample of small and innovative Finnish manufacturing and service firms, our study finds that the benefits of patenting strongly depend on firm size. Most small firms are not able to benefit from patents, and, consequently, their choice of primary appropriability mechanism is between secrecy and speed. Process innovators and firms in higher technology industries are more likely to emphasize trade secrets, while the smallest firms and those in lower technology industries are likely to rely on speed to market. Even highly R&D intensive small firms are no more likely than their less innovative counterparts to choose patents as their preferred mechanism to protect intellectual assets. Instead, R&D intensive small firms tend to rely on speed rather than patents or secrecy, but, on the other hand, small firms in R&D intensive industries tend to prefer secrecy to protect their innovations. In other words, firms that are more R&D intensive than their industry peers are the most likely to prefer speed to market as a means of appropriability.

We also find strong evidence that vertical innovation cooperation has significant implications for appropriability strategy. In particular, firms with vertical collaborative innovation arrangements are statistically significantly more likely than other firms to rely on speed instead of secrecy to appropriate innovation returns. We interpret this in the light of small firms' bargaining power within vertical cooperative arrangements. The firms in our sample are most probably dealing with partners larger than themselves, in which case they are in a relatively weak position to appropriate intellectual outputs from joint work. Moreover, as previously stated, patenting may not be a feasible strategy simply for lack of resources to apply for and defend patents. In an intense cooperative arrangement, secrecy is not likely to work either, inasmuch as partners are able to learn and pass on to third parties the technology secrets of the focal small firm. Hence, firms with cooperative innovation projects with vertical partners are found to rely mostly on speed to market.

The rest of the paper is organized as follows. We first discuss the state of the literature on appropriability and interfirm cooperation and articulate a set of existing and new hypotheses about small firms' strategies to protect innovation returns. Then we introduce the Finnish survey dataset of small firms and carry out the empirical analyses. The last section discusses the implications of our empirical results and concludes.

2 Recent literature on appropriability

A number of studies have been completed to gain an understanding of how firms choose between the various mechanisms for the appropriation of the benefits from innovative activities. These studies show that the type of innovative activity along with both firm and industry characteristics play important roles in a firm's choice of primary appropriability mechanism.

Harabi (1995) defines five appropriability mechanisms: patents, secrecy, lead time, moving quickly down the learning curve, and sales and service efforts. While firms generally rank patents as inferior to other appropriability mechanisms (Cohen, Nelson, & Walsh, 2000; Harabi, 1995), certain firm characteristics or strategies may nevertheless give rise to reliance on patenting to protect innovations. In particular, firm size, high investments in research and development, and engaging in inter-firm cooperation are found to increase the likelihood of patenting (Brouwer & Kleinknecht, 1999; Cohen et al., 2000; Arundel, 2001). Additionally, product innovations are more likely to be patented than process innovations, which are usually more effectively protected with trade secrets (Harabi, 1995). A process innovation is more easily kept within a firm, while a product must be released to the market at large. Therefore, for process innovations, the legal protection offered by patents may not be worth the mandatory disclosure of information about the innovation associated with the patent application.

Arundel (2001) argues that while larger firms are more likely to patent, smaller firms rely mainly on secrecy to protect their innovations. Small firms often lack the resources necessary to legally defend their patents when necessary (Cohen et al. 2000), and moreover, their patent enforcement costs are likely to be higher because they rarely benefit from cross-licensing arrangements or aggressive IPR strategy reputation effects (Lanjouw & Schankerman, 2001). Overall, however, large firms tend to rate all appropriability mechanisms as more effective than do small firms (Arundel, 2001). Small firms thus appear to perceive the “same” industrial environment as weaker for appropriability than do large firms—who simply have more resources and market power to defend their intellectual property.

Another firm characteristic that may influence the choice of appropriability mechanism is involvement in inter-firm cooperation. Firms that engage in cooperative arrangements with other firms benefit from both specialized knowledge of their partners and the interactive learning that takes place in a joint R&D project (Sobrero & 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 potential partners over cross-licensing arrangements and the ownership of the joint R&D output (Cohen et al. 2002). For smaller firms, however, patenting may not be an option due to aforementioned resource constraints, and, consequently, larger cooperation partners may use their bargaining power to demand ownership of intellectual property that results from joint innovation. Indeed, Cassiman and Veugelers (2002) suggest that vertical cooperation is negatively associated with the effectiveness of all appropriability mechanisms. Along with weaker bargaining ability of small firms, this leads us to expect that small firms that have cooperative arrangements with suppliers or clients would not find the use of patents or trade secrets particularly advantageous.

Industry-specific characteristics also influence a firm's choice of appropriability mechanism. For example, according to Brouwer and Kleinknecht (1999), firms' propensity to patent is higher in high technology industries than in other industries. 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, have few components, and as such, innovations in these areas are simpler to protect by patents. In contrast, complex products, for example, electronics products or machinery, may require many different components in their construction or development. Cohen et al. argue that an innovation in these areas often requires licensing or other arrangements to gain access to technologies from other firms, making commercializing an innovation more challenging. Therefore, patenting is pursued in complex product industries for strategically different reasons than in discrete product industries. However, small firms typically don't have extensive patent portfolios to cross-license from, which makes operating in a complex product environment difficult. This may induce small complex product firms to steer away from technologies and products where such 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 typically much easier to invent around technologies in the engineering-based industries that Cohen et al. call complex product industries than it is in discrete product industries. This reduces the incentive to patent, and may make firms more inclined to rely on time to market as the competitive asset.

In the empirical analyses to follow, we utilize data from a survey of small Finnish firms.[2] Four explicit appropriability mechanisms 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 for protecting their innovations. We attempt to explain small firms' choice of preferred appropriability mechanism with a set of firm- and industry-level characteristics. Explanatory firm-level variables include firm size, R&D expenditures, exports, type of innovation (product or process), and cooperative arrangements. Industry-specific variables include technology sector dummies for firms in high technology manufacturing industries, medium-high technology manufacturing industries, high technology and R&D intensive service industries, and other industries. We also divide the firms in the sample into discrete and complex product firms using the Cohen et al. (2000) approach.

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[2] Fewer than 100 employees, of which a large majority have fewer than 50 employees.

Based on the literature reviewed above, we expect that firms in high technology and discrete product industries are more likely than those in lower technology or complex product industries to rate patents as their most important appropriability mechanism. We also expect that being involved in product innovation increases the likelihood of rating patents as the most effective appropriability mechanism, while secrecy is expected to be more effective for process innovations. It is also possible, however, that small firms rely on secrecy to protect both product and process innovations (Arundel, 2001). Furthermore, we expect a larger firm size to increase the likelihood of rating patents as the preferred appropriability mechanism.

To examine the effect of small firms' external relationships on their appropriability strategies, we utilize survey information concerning firms' engagement in cooperative innovation activities with competitors or with other firms (clients, suppliers, or other commercial organizations). 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 have these kinds of partnerships with (usually larger) suppliers and clients. The reason for focusing on these relationships is that both vertical innovation cooperation and vertical partnerships are likely to expose a great deal of the focal firm's proprietary know-how to the partner. Furthermore, the cooperation partner's most likely stronger bargaining power may put the small firm at a disadvantage in terms of defending its intellectual assets against appropriation by the partner. Small firms may not have the resources to patent their intellectual property and thereby establish more explicit legal rights. Then, neither patents nor secrecy may be viable options for protecting their innovations. Instead, we expect to find that speed to market is the only recourse of innovative firms in intensive partnerships or cooperative innovation arrangements.

3 The dataset of small knowledge-intensive Finnish firms

The survey data were collected by ETLA and are described in detail by Hyytinen and Pajarinen (2003; 2005). Hyytinen and Toivanen (2005) utilized the same database in their study of small innovating firms' financial constraints. The first survey wave collected in 2002 sampled 2 600 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, therefore, oversamples firms in high technology, medium high technology, and information intensive service sectors relative to the entire population of small Finnish firms. These kinds of firms account for about 60 percent of the sample. The second survey, collected in 2003, targeted the respondents from the previous survey, resulting in 830 responses. The main purpose of the second survey was to identify the consumption of publicly provided business services by small and medium-sized Finnish firms.

From the first survey, we use the information about the number of employees, research and development expenditures, partnerships with clients and suppliers, innovation activities, technology classifications, and export orientation. The data cover the years 2000 or 2001, depending which was the most recent year of data available to the survey respondent. Descriptions of all variables are shown in table 1**.**

TABLE 1 ABOUT HERE

Firm size is measured by the number of employees in the firm. The average firm in the estimation samples has about 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 outcomes were determined through a set of binary questions. Firms were asked whether they had introduced a process innovation in the previous three years, and similarly for product innovations. EXPORTS is also a binary variable indicating whether the firm reported exporting any products. To assess the role of vertical relationships, firms were asked whether they had a client or a supplier that accounted for more than one third of their sales or procurement. We combine these answers to create a binary variable, PARTNER, which takes the value unity if the firm identifies either a client that accounts for more than one third of sales or a supplier that accounts for more than one third of its procurement and zero otherwise. About half of the firms in the sample have such intensive partnerships.[3]

Another aspect of vertical dependence is represented by cooperative innovation arrangements. Our measures of firms' cooperative activities are taken from the second (2003) survey. Firms were asked whether they had cooperated in innovative activities with firms in the same industry and whether they had cooperated with supplier, clients, or consultants. The variable, COOP HORZ, indicates whether the firm answered the first question affirmatively, while COOP VERT indicates if the firm answered the second question affirmatively. About half of the sampled firms engaged in vertical cooperation and two thirds in horizontal cooperation. It is thus very common for innovative small firms to cooperate in their R&D activities.

[3] An earlier analysis separated PARTNER 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 partner.

Technology class definitions are taken directly from Hyytinen and Pajarinen (2003) who use the OECD definitions to create dummies for high technology (HIGH TECH) and medium-high technology (MEDIUM HIGH TECH) manufacturing industries. A separate dummy is also defined for R&D or technology intensive services (R&D SERVICES: telecommunications, software, R&D services, and technical services), while the reference group includes low technology manufacturing industries. Additionally, DISCRETE is an indicator for firms whose products fit Cohen's (1991) definition of discrete products.

Finally, the dependent variables come from the 2003 survey, where firms were asked which appropriability mechanism was the most important to them: patents, secrecy, complementary production or services, speed (being faster to market than competitors), or other appropriability mechanisms. The variables PATENTS, SECRECY, and SPEED are thus mutually exclusive binary variables. Over half of the sample prefers speed to market as a means to protect innovations, about a quarter of the firms prefer patents, while only 17 percent of them prefer secrecy. Thus, the majority of the sampled firms protect their innovations outside of the legal intellectual property rights system.[4]

To keep our focus on small firms, we remove 32 firm observations that had more than 100 employees and 1 observation with 5 million Euros in R&D expenditures, which was nearly twice the magnitude of the next largest observation. Then, combining the two surveys results in 773 observations of firms that participated in both surveys. However, data were unavailable for 347

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

observations on the cooperation variables, 139 observations on R&D expenditures, 100 observations on the dependent variables, and 1 observation on the industry classification. After deleting observations with missing data, our final estimation sample contains 312 observations. If the cooperation variables are not included, we can use a secondary sample of 533 observations. Table A1 in the appendix shows summary statistics for all 773 available observations, and tables 2 and 3 below display summary statistics for the two estimation samples; with or without the cooperation variables.

TABLE 2

TABLE 3

The summary statistics show some biases in the estimation samples relative to all available observations. When the cooperation variables are not included, the sample of 533 observations shows a slight bias toward R&D intensive firms. The mean of R&D expenditures is 72 186 euros compared to 66 705 euros for the full set of observations. The final estimation sample of 312 firms, however, shows more significant differences. The mean of R&D expenditures for the estimation sample is 112 246 euros. Lower R&D spending firms were thus less likely to complete the full survey. The smaller estimation sample also contains a greater proportion of exporters (50 percent vs. 38 percent), a greater proportion of product innovators (29 percent vs. 22 percent) and a correspondingly greater proportion of firms that introduced both product and process innovations (33 percent vs. 21 percent) than the sample of all available observations. Finally, the smaller estimation sample contains a lower proportion of firms from discrete product industries (15 percent vs. 21 percent) and greater proportions of high technology firms and R&D

intensive service firms (14 percent vs. 11 percent, and 29 percent vs. 20 percent, respectively). All other discrepancies are within two percent. In sum, the final estimation sample of 312 observations is somewhat biased towards innovation- and export-intensive firms. However, we believe this bias is not a serious problem since 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 natural. It is nevertheless useful to keep in mind when interpreting the results that they apply to a set of randomly sampled innovation-oriented and high technology-based small firms.

4 Empirical analyses of the choice of appropriability strategy

We begin by estimating simple probit models for each of the identified appropriability mechanisms. We model the discrete choice of each appropriability mechanism as a function of the number of employees, R&D expenditures (recorded as their natural logarithms, with zero expenditures set at zero), interfirm cooperation, exports, and technology class:

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

where the ε are iid random variables.

We present three specifications of each discrete choice model. While we are particularly interested in the effects of interfirm cooperation on the choice of appropriability mechanism, the survey dataset contains many missing observations on vertical and horizontal cooperation.

Therefore, for each appropriability mechanism, we build toward the final model by adding variables. Model 1 is estimated with all of the variables described above except PARTNER and the cooperation variables. PARTNER is added in model 2, and in model 3 we add the cooperation variables.

The results from the probit models for PATENTS, SECRECY, and SPEED are presented in tables 4, 5, and 6, respectively. The patent models in table 4 display a strong positive relationship between firm size as measured by the number of employees and the probability that a firm will rate patents as their most effective appropriability mechanism, significant at the 99 percent confidence level in all three specifications. None of the other variables is significant. Partner and cooperation variables do not seem to add any valuable information, either. We can judge the overall fit of these regressions by calculating the proportion of correct predictions of the dependent variable. For this regression, even though all three models predict roughly 73 percent of observations correctly, this is not much better than blindly guessing that no firms rated patents as the most effective appropriability mechanism (72.8 percent correctly classified). Thus, we conclude that the overall fit of this model is rather poor. Moreover, the likelihood ratio test, which tests the hypothesis that all coefficients are simultaneously zero cannot be rejected for model 3.

TABLE 4

The results are slightly stronger for the secrecy models (table 5). Here, firms with limited R&D expenditures are likely to rate secrecy as their most important appropriability mechanism.

Furthermore, consistent with earlier studies, model 3 shows that firms with process innovations are weakly more likely to rely on secrecy to appropriate the returns from their innovative activities. The results for the secrecy model also show that firms with cooperative innovation arrangements with suppliers or clients are less likely to choose secrecy as their most important appropriability mechanism. This lends support for our hypothesis that for SME's with vertical cooperative arrangements involving innovative activities, trade secrets may not be a viable appropriation strategy.

TABLE 5

As far as the industry characteristics, we find that firms in discrete product industries are highly likely to rate secrecy as their most important appropriability mechanism, contrary to Cohen's observation that these firms generally are likely to benefit from blocking competitors from imitating. However, this is consistent with our hypothesis that small firms generally tend to find patents financially prohibitive. Finally, all technology class dummies show a positive relationship with the choice of secrecy as the most effective appropriability mechanism, with the coefficients on high technology manufacturing and R&D intensive services significant at the 95 percent level, relative to the base case of low technology firms.

The secrecy models correctly classify between 83 percent and 84 percent of the observations in the sample. These numbers are similar to the blind guess of no firms indicating secrecy as their most effective appropriability mechanism (83.7 percent correctly classified). However, the likelihood ratio test rejects the hypothesis that all coefficients are simultaneously zero at the 99 percent confidence level for all three specifications.

The results for the last set of probit models suggest a negative relationship between the choice of speed as the most important appropriability mechanism and all three technology class dummies (table 6). Firms making discrete products are also significantly less likely to prefer speed. In complex product industries, patents are used defensively (Hall & Ziedonis, 2001) which requires deep patent portfolio and other resources unlikely to be available to the sampled firms. The coefficients for the EMPLOYEES variable imply that that the smallest firms are the most likely to choose speed to market as their most important appropriability method. The second specification for speed also shows a positive relationship between speed and the existence of an intensive vertical partnership, but this result is not robust to specification as its magnitude and significance decline when the cooperation variables are added in model 3. The coefficient on the vertical cooperation variable is positive and significant at the 90 percent level. There is thus weak evidence that speed is the choice appropriability mechanism for SME's with vertical cooperative innovation arrangements. The results for the speed models also show that firms with higher R&D expenditures are weakly more likely to prefer speed.

TABLE 6

The speed model correctly classifies 61.54 percent of the observations, which is better than a blind guess of no firms choosing speed as their most important appropriability mechanism (50.32

percent correctly classified). A likelihood ratio test rejects the hypothesis that all coefficients are simultaneously zero at the 95 percent confidence level.

The mutually exclusive nature of our dependent variables in the probit models allows us to further examine the choice of appropriability mechanism through the estimation of a multinomial logit model. The multinomial logit method takes into account the other alternatives when estimating the effects of the factors behind any one choice, thus giving us a clearer view of the respondents' choice situation. These results are presented in table 7**.** Because very few firms indicated complementary production or services or "other" as their most important appropriability mechanism, we combine the two responses and include them in SPEED. SPEED AND OTHER is the base case for comparison. The likelihood ratio test rejects the hypothesis that all coefficients are simultaneously zero at the 99 percent confidence level for all three specifications. The Hausman test for the IIA assumption is accepted, implying that the results are invariant to dropping any of the alternatives from the models.

TABLE 7

The multinomial logit results are broadly aligned with the probit models. One of the few differences involves the coefficient for discrete products that is positive and significant for PATENTS in models 1 and 3, but this is not robust to adding the vertical relationship variables (and simultaneously estimating using the smaller sample). Meanwhile, taking into account other appropriability choices, the main drivers of the choice of SECRECY as the preferred appropriability mechanism remain process innovations, discrete technology products, and affiliation with a high-technology or R&D service industry. Firms with a vertical innovation arrangement, on the other hand, are significantly less likely to choose secrecy.

We also computed the marginal effect of each variable on the three appropriability mechanisms for specification 3 that includes the cooperation variables. Table 8 shows the marginal effects computed at the mean of the data set for both the probit and multinomial logit models.[5] Interestingly, there is little difference in the estimated marginal effect of each variable between the two estimation techniques. The largest impacts on the probability of choosing either speed or secrecy come from the technology and industry class variables, with nearly equal and opposite effects on each. Affiliation with discrete products, high technology, or R&D service industries each increase the probability of choosing secrecy by 17, 23, and 17 percentage points, respectively. These same affiliations decrease the probability of choosing speed by 21, 23, and 20 percentage points respectively.

The sectoral and technology classes are interesting in that they explain a large degree of the differences between firms that choose secrecy and those that choose speed as their most important appropriability mechanism, but they are not choice variables for firms. One of the few strategic drivers for the choice between secrecy and speed in this set of small innovative Finnish firms seems to be the presence of a vertical R&D cooperative arrangement. This decreases the probability that a firm will choose secrecy as its most important appropriability mechanism by 11 percentage points and, according to the probit model, increases the probability of choosing speed by 10 percentage points. As argued previously, by sheer probability, these small firms are quite likely to partner with firms larger than themselves. We speculate that bargaining power

[5] A marginal effect for dummy variables implies the change in probability when the dummy is turned on.

differences make it difficult for the small firm to keep trade secrets or establish rights to emerging intellectual property. Speed to market may then be a more feasible means of appropriating the returns to R&D investment.

We also estimated models using two-digit sector dummies in place of the technology classes we defined above. Other models were also estimated, where R&D expenditures were replaced with the ratio of R&D expenditures to the industry average R&D expenditure at the two-digit level to capture the possible effects of R&D expenditures relative to similar firms, given that the data set is quite diverse in terms of the number of industries surveyed. None of these models changed or added significantly to our results.[6]

5 Discussion and conclusion

This study demonstrates that few of the smallest firms benefit from patenting, even if they are R&D intensive, innovative, cooperate in R&D, or operate in discrete or high technology industries. Only firm size explains the preference to use patents to protect innovations in our sample of small firms. Instead, the strategic choices for most small firms are between speed to market and secrecy. Speed is the appropriability method of choice for the smallest and for the highly R&D intensive firms, as well as for firms operating in lower technology industries and for firms that cooperate vertically in their innovation activities. In particular, cooperative arrangements make it difficult to protect trade secrets; the recourse is to benefit from innovation by being faster than competitors. Moreover, our results suggest that only cooperative innovation

[6] These results are available from the authors upon request.

arrangements have implications for appropriability strategies, while simply being highly dependent on a vertical partner (a client or a supplier) in regular business activities does not. Secrecy, on the other hand, is preferred by firms offering products based on discrete (as opposed to complex) technologies and by firms with low R&D effort but operating in high technology or R&D based service industries. The result concerning discrete products industries is intuitive in that firms in these industries depend less on technological inputs from their peers and may thus be able to maintain secrecy. Horizontal flows of technological knowledge are likely to be more substantial in complex product industries such as electronics.

These results for a sample consisting mostly of high or medium high technology manufacturing firms and R&D intensive service firms imply that our understanding of the workings of the intellectual property rights system has to be revised when it comes to small firms. The patent system is generally viewed as the cornerstone of socially beneficial incentives for innovative activity (and their partial disclosure), yet it appears to work remarkably poorly in protecting the returns on innovation activities of the smallest firms. At the same time, however, innovative SMEs are believed to be the key factor behind sustained growth of the economy and employment (e.g., European Commission, 2001, 2003, 2006; see also Audretsch, 2004). This raises some serious innovation policy questions. In particular, how can intellectual property rights policies encourage small firms' innovation investments? Some possible solutions include that the patent system be modified to enable access for innovators without abundant resources to apply for and defend patents. For example, patenting fees could be defined on a sliding scale depending on the applicant's resources, 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).

Another, perhaps more surprising, result from this current study is that most small innovating firms do not perceive secrecy as a very effective means to protect their intellectual assets. One of the key factors behind this is the engagement in cooperative vertical innovation arrangements. As many innovative SMEs engage in cooperative R&D, and secrecy is difficult to maintain in joint projects while patents are too expensive to defend, the only recourse is to appropriate returns to innovation by quick market launch. Moreover, vertical cooperation arrangements appear to have more significant repercussions for IPR strategies than do horizontal ones. We speculate this has to do with the bargaining power differentials with and financial dependence on key suppliers and clients. Horizontal cooperation arrangements are rarely associated with equally significant dependence on external parties. Thus, for vertically cooperating small innovating firms, patenting is not an option because of resource constraints, while trade secrets are not feasible because of intensive interaction with and dependence on vertical innovation partners. The only recourse is to commercialize the results of R&D ahead of competitors who may receive spillovers through the vertical partners.

The relationship between vertical innovation cooperation and appropriability through speedy market access also has 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. However, if these projects involve vertical relationships, then small firms are highly likely to attempt to speed up market launch rather than rely on secrecy or patents for protection. National innovation programs may thus influence the appropriability strategies of participating firms, depending on what kinds of mandates for inter-firm cooperation are specified. Our results would suggest that technology programs involving vertical R&D cooperation might lead to faster commercialization than those with horizontal or no R&D cooperation.

Whereas this study is based on a sample from a small European economy, many of its results are aligned with earlier studies with different kinds of samples. This increases our confidence in the generalizability of the results. The novelty of this research is its explicit focus on small firms and their vertical dependencies. The results obtained provide a striking view of the driver behind successful patenting—firm size—and the recourse by small firms to alternative means for appropriating the returns on their innovation investments—in the majority of cases speed to market. Indeed, the sampled firms on average find trade secrets, too, to be difficult to benefit from. We thus conclude that the emphasis on patents in the debates concerning the institutional environment for innovation may be misplaced. More theoretical and empirical research is needed into the implications for market, R&D investment, and innovation outcomes of speed to market as the key appropriability mechanism for small firms. Finally, while 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 account for any remaining endogeneities. For example, the mechanisms behind the results on vertical cooperative innovation activities would be interesting to examine in more detail. The significance of vertical innovation arrangements over other vertical partnerships may in part be driven by simultaneity of the cooperation and appropriability variables. This could be assessed with longitudinal data.

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Table 1
Variable descriptions

Appropriability mechanisms	**Description**
PATENTS	Patents are the most important appropriability mechanism
SECRECY	Secrecy is the most important appropriability mechanism
SPEED	Speed to market is the most important appropriability mechanism
OTHER APPRO	Complementary production, products, services or other means are the most important appropriability mechanism
Continuous variables	
EMPLOYEES	Number of Employees
R&D Expenditures	R&D expenditures (Euros)
Log (R&D)	Natural logarithm of R&D expenditures (Euros), 0 R&D expenditures set to 0
Binary variables	
EXPORTS	1 if firm has any exports, 0 otherwise
PRODUCT INNOVATION	1 if firm claims only a product innovation in past three years, 0 otherwise
PROCESS INNOVATION	1 if firm claims only a process innovation in past three years, 0 otherwise
BOTH INNOVATION	1 if firm claims both product and process innovations in past three years, 0 otherwise
COOP HORZ	1 if firm has cooperated in innovation with firms in the same industry, 0 otherwise
COOP VERT	1 if firm has cooperated in innovation with suppliers, clients, or consultants, 0 otherwise
PARTNER	1 if firm has either a client with share of sales or a supplier with share of procurement greater than 33%, 0 otherwise
DISCRETE	Discrete products, 1 if firms has SIC < 2900, 0 otherwise
HIGH TECH	1 if firm is classified as a "high tech" business, 0 otherwise
MED HIGH TECH	1 if firm is classified as a "medium high tech" business, 0 otherwise
R&D SERVICES	1 if firm is classified as a "R&D and technology intensive services" business, 0 otherwise

Table 2
Summary statistics for estimation sample 1 (N=533)

Variable	Mean	St. Dev.	Min	Max
R&D expenditures (Euros)	72 185.64	201 014.5	0	2 356 906
EMPLOYEES	12.8330	15.4386	1	97
EXPORTS	0.3865	0.4874	0	1
PRODUCT INNOVATION	0.2120	0.4091	0	1
PROCESS INNOVATION	0.0901	0.2865	0	1
BOTH INNOVATION	0.2345	0.4241	0	1
PARTNER	0.5159	0.5002	0	1
DISCRETE	0.2008	0.4009	0	1
HIGH TECH	0.1201	0.3254	0	1
MED HIGH TECH	0.2795	0.4492	0	1
R&D SERVICES	0.2026	0.4023	0	1
PATENTS	0.2645	0.4415	0	1
SECRECY	0.1670	0.3733	0	1
SPEED	0.5685	0.4958	0	1

Table 3
Summary statistics for estimation sample 2 (N=312)

Variable	Mean	St. Dev.	Min	Max
R&D expenditures (Euros)	112 245.9	251 099.2	0	2 356 906
EMPLOYEES	13.6442	16.6264	1	97
EXPORTS	0.4936	0.5008	0	1
PRODUCT INNOVATION	0.2949	0.4567	0	1
PROCESS INNOVATION	0.0769	0.2669	0	1
BOTH INNOVATION	0.3365	0.4733	0	1
PARTNER	0.5000	0.5008	0	1
COOP HORZ	0.6635	0.4733	0	1
COOP VERT	0.5192	0.5004	0	1
DISCRETE	0.1506	0.3583	0	1
HIGH TECH	0.1442	0.3519	0	1
MED HIGH TECH	0.2949	0.4567	0	1
R&D SERVICES	0.2853	0.4523	0	1
PATENTS	0.2724	0.4459	0	1
SECRECY	0.1635	0.3704	0	1
SPEED	0.5641	0.4967	0	1

Table 4
Probit results for PATENTS

	MODEL 1		MODEL 2		MODEL 3	
N	533		533		312	
Log Likelihood	-298.3609		-297.8220		-174.4820	
LR	19.16	**	20.24	**	16.49	
Correctly classified	73.73%		73.55%		73.08%	
VARIABLE	**Coefficient**		**Coefficient**		**Coefficient**	
Log(R&D)	0.0164		0.0160		-0.0032	
	(0.0154)		(0.0155)		(0.0221)	
EMPLOYEES	0.0091	**	0.0088	**	0.0126	***
	(0.0039)		(0.0039)		(0.0047)	
EXPORTS	0.0385		0.0262		0.1907	
	(0.1350)		(0.1357)		(0.1739)	
PRODUCT INNOVATION	-0.0356		-0.0362		-0.0482	
	(0.1736)		(0.1739)		(0.2186)	
PROCESS INNOVATION	0.2420		0.2484		0.0497	
	(0.2160)		(0.2165)		(0.3196)	
BOTH INNOVATION	-0.0375		-0.0369		-0.0680	
	(0.1703)		(0.1704)		(0.2192)	
PARTNER			-0.1244		-0.0089	
			(0.1199)		(0.1580)	
COOP HORZ					0.1047	
					(0.1711)	
COOP VERT					0.0785	
					(0.1596)	
DISCRETE	0.2058		0.2140		0.2194	
	(0.1680)		(0.1681)		(0.2374)	
HIGH TECH	0.0175		0.0290		-0.0197	
	(0.2174)		(0.2182)		(0.2785)	
MED HIGH TECH	0.2068		0.2146		0.1729	
	(0.1670)		(0.1673)		(0.2339)	
R&D SERVICES	-0.0112		-0.0079		-0.0265	
	(0.1989)		(0.1991)		(0.2526)	
Constant	-0.9951	***	-0.9277	***	-1.0144	***
	(0.1356)		(0.1500)		(0.2566)	

*, **, *** signify significance at 90%, 95%, and 99% level of confidence
(Standard errors in parentheses)

Table 5
Probit results for SECRECY

	MODEL 1	MODEL 2	MODEL 3
N	533	533	312
Log Likelihood	-226.5788	-225.8454	-120.4851
LR	27.68 ***	29.14 ***	36.94 ***
Correctly classified	83.30%	83.30%	84.29%
VARIABLE	**Coefficient**	**Coefficient**	**Coefficient**
Log(R&D)	-0.0463 ***	-0.0469 ***	-0.0500 **
	(0.0166)	(0.0167)	(0.0240)
EMPLOYEES	0.0026	0.0022	0.0011
	(0.0047)	(0.0047)	(0.0061)
EXPORTS	-0.1825	-0.2041	-0.2910
	(0.1571)	(0.1587)	(0.2130)
PRODUCT INNOVATION	-0.2432	-0.2446	-0.2284
	(0.2042)	(0.2049)	(0.2684)
PROCESS INNOVATION	0.1842	0.2019	0.6285 *
	(0.2460)	(0.2462)	(0.3376)
BOTH INNOVATION	0.2557	0.2561	0.2808
	(0.1845)	(0.1851)	(0.2507)
PARTNER		-0.1646	-0.1673
		(0.1361)	(0.1907)
COOP HORZ			-0.1588
			(0.1966)
COOP VERT			-0.5414 ***
			(0.1912)
DISCRETE	0.5299 ***	0.5340 ***	0.6442 **
	(0.1875)	(0.1878)	(0.2673)
HIGH TECH	0.7773 ***	0.8038 ***	0.8159 ***
	(0.2333)	(0.2344)	(0.3091)
MED HIGH TECH	0.4169 **	0.4353 **	0.2674
	(0.1910)	(0.1920)	(0.2839)
R&D SERVICES	0.6979 ***	0.7033 ***	0.6829 **
	(0.2215)	(0.2219)	(0.2924)
Constant	-1.1554 ***	-1.0687 ***	-0.6620 **
	(0.1529)	(0.1683)	(0.2902)

*, **, *** signify significance at 90%, 95%, and 99% levels of confidence
(Standard errors in parentheses)

Table 6
Probit results for SPEED

	MODEL 1	MODEL 2	MODEL 3
N	533	533	312
Log Likelihood	-349.6747	-348.0552	-199.3888
LR	29.52 ***	32.75 ***	28.60 ***
Correctly classified	60.98%	62.66%	64.10%
VARIABLE	**Coefficient**	**Coefficient**	**Coefficient**
Log(R&D)	0.0186	0.0195	0.0363 *
	(0.0143)	(0.0144)	(0.0208)
EMPLOYEES	-0.0098 **	-0.0093 **	-0.0130 ***
	(0.0039)	(0.0039)	(0.0049)
EXPORTS	0.0732	0.0935	-0.0029
	(0.1285)	(0.1293)	(0.1665)
PRODUCT INNOVATION	0.1458	0.1442	0.1401
	(0.1635)	(0.1641)	(0.2087)
PROCESS INNOVATION	-0.3383	-0.3531 *	-0.4917 *
	(0.2116)	(0.2125)	(0.3066)
BOTH INNOVATION	-0.1580	-0.1593	-0.1107
	(0.1578)	(0.1582)	(0.2058)
PARTNER		0.2027 *	0.0634
		(0.1127)	(0.1500)
COOP HORZ			0.0315
			(0.1612)
COOP VERT			0.2444 *
			(0.1497)
DISCRETE	-0.5027 ***	-0.5168 ***	-0.5832 ***
	(0.1600)	(0.1607)	(0.2318)
HIGH TECH	-0.5327 ***	-0.5572 ***	-0.5093 **
	(0.2003)	(0.2013)	(0.2609)
MED HIGH TECH	-0.4460 ***	-0.4622 ***	-0.3780 *
	(0.1581)	(0.1587)	(0.2263)
R&D SERVICES	-0.4421 **	-0.4512 **	-0.4244 *
	(0.1831)	(0.1838)	(0.2357)
Constant	0.5665 ***	0.4572 ***	0.2809
	(0.1245)	(0.1385)	(0.2387)

*, **, *** signify significance at 90%, 95%, and 99% levels of confidence
(Standard errors in parentheses)

Table 7
Multinomial logit results

	MODEL 1		MODEL 2		MODEL 3	
N	533		533		312	
Log Likelihood	-492.7725		-491.1899		-275.9252	
LR	50.31***		53.47***		55.48***	
	PATENTS	**SECRECY**	**PATENTS**	**SECRECY**	**PATENTS**	**SECRECY**
Hausmann IIA	-3.832	0.29	9.751	-0.632	8.615	0.03
VARIABLE	**Coeff**	**Coeff**	**Coeff**	**Coeff**	**Coeff**	**Coeff**
Log(R&D)	0.0061	-0.0859 ***	0.0048	-0.0873 ***	-0.0329	-0.1078 **
	(0.0277)	(0.0314)	(0.0278)	(0.0316)	(0.0398)	(0.0457)
EMPLOYEES	0.0176 ***	0.0114	0.0170 **	0.0105	0.0239 ***	0.0126
	(0.0068)	(0.0090)	(0.0068)	(0.0091)	(0.0086)	(0.0120)
EXPORTS	-0.0031	-0.3056	-0.0382	-0.3394	0.2324	-0.3871
	(0.2370)	(0.2961)	(0.2392)	(0.2983)	(0.3072)	(0.4005)
PRODUCT INNOVATION	-0.1270	-0.4749	-0.1270	-0.4725	-0.1469	-0.4413
	(0.3034)	(0.3915)	(0.3047)	(0.3929)	(0.3864)	(0.5085)
PROCESS INNOVATION	0.5481	0.5656	0.5680	0.5928	0.4493	1.2936 *
	(0.3828)	(0.4704)	(0.3834)	(0.4708)	(0.5986)	(0.6366)
BOTH INNOVATION	0.0882	0.5289	0.0922	0.5277	0.0045	0.5416
	(0.2980)	(0.3427)	(0.2992)	(0.3445)	(0.3853)	(0.4731)
PARTNER			-0.2978	-0.3631	-0.0448	-0.2696
			(0.2121)	(0.2532)	(0.2798)	(0.3549)
COOP HORZ					0.1064	-0.2915
					(0.3046)	(0.3656)
COOP VERT					-0.0855	-0.9967 ***
					(0.2796)	(0.3638)
DISCRETE	0.6079 **	1.1639 ***	0.6319	1.1831 ***	0.7065 *	1.4697 ***
	(0.2985)	(0.3584)	(0.2999)	(0.3588)	(0.4295)	(0.5127)
HIGH TECH	0.3905	1.5677 ***	0.4308	1.6144 ***	0.3505	1.6597 ***
	(0.3903)	(0.4373)	(0.3918)	(0.4391)	(0.5029)	(0.5996)
MED HIGH TECH	0.5552 *	0.9812 ***	0.5787 *	1.0112 ***	0.4748	0.7569
	(0.2946)	(0.3695)	(0.2960)	(0.3706)	(0.4122)	(0.5515)
R&D SERVICES	0.2853	1.4068 ***	0.3039	1.4144 ***	0.2700	1.4497 **
	(0.3543)	(0.4236)	(0.3553)	(0.4244)	(0.4498)	(0.5726)
Constant	-1.4791 ***	-1.8452 ***	-1.3179 ***	-1.6488 ***	-1.2746 ***	-0.9826 *
	(0.2427)	(0.3009)	(0.2669)	(0.3274)	(0.4589)	(0.5556)

*, **, *** signify significance at 90%, 95%, and 99% levels of confidence

(Standard errors in parentheses)

Table 8
Marginal Effects

	PATENTS		**SECRECY**		**SPEED**[7]	
	PROBIT	MLOGIT	PROBIT	MLOGIT	PROBIT	MLOGIT
Variable	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
Log(R&D)	-0.0011	-0.0028	-0.0106 **	-0.0109 **	0.0144 *	0.0136
	(0.0072)	(0.0076)	(0.0051)	(0.0048)	(0.0083)	(0.0084)
EMPLOYEES	0.0041 ***	0.0044 ***	0.0002	0.0006	-0.0031	-0.0049 ***
	(0.0015)	(0.0016)	(0.0013)	(0.0013)	(0.0019)	(0.0020)
EXPORTS	0.0624	0.0607	-0.0613	-0.0516	0.0061	-0.0091
	(0.0568)	(0.0594)	(0.0446)	(0.0430)	(0.0657)	(0.0659)
PRODUCT	-0.0157	-0.0147	-0.0457	-0.0416	0.0230	0.0564
INNOVATION	(0.0706)	(0.0742)	(0.0506)	(0.0485)	(0.0820)	(0.0812)
PROCESS	0.0165	0.0181	0.1721	0.1755	-0.1558 *	-0.1936
INNOVATION	(0.1072)	(0.1143)	(0.1119)	(0.1162)	(0.1145)	(0.1240)
BOTH	-0.0221	-0.0200	0.0624	0.0647	-0.1216	-0.0447
INNOVATION	(0.0707)	(0.0732)	(0.0584)	(0.0575)	(0.0802)	(0.0822)
PARTNER	-0.0029	0.0007	-0.0353	-0.0286	0.0686	0.0279
	(0.0517)	(0.0544)	(0.0401)	(0.0382)	(0.0591)	(0.0594)
COOP HORZ	0.0339	0.0320	-0.0345	-0.0379	0.0338	0.0059
	(0.0547)	(0.0576)	(0.0440)	(0.0424)	(0.0636)	(0.0639)
COOP VERT	0.0257	0.0198	-0.1159 ***	-0.1112 ***	0.1033 *	0.0914
	(0.0521)	(0.0537)	(0.0406)	(0.0401)	(0.0587)	(0.0591)
DISCRETE	0.0750	0.0634	0.1703 **	0.1799 **	-0.2194 ***	-0.2433 ***
	(0.0843)	(0.0864)	(0.0829)	(0.0873)	(0.0842)	(0.0904)
HIGH TECH	-0.0064	-0.0258	0.2272 **	0.2485 **	-0.2272 **	-0.2227 **
	(0.0903)	(0.0930)	(0.1030)	(0.1162)	(0.0929)	(0.1056)
MED HIGH TECH	0.0578	0.0661	0.0600	0.0726	-0.1587 *	-0.1386
	(0.0797)	(0.0837)	(0.0676)	(0.0705)	(0.0863)	(0.0909)
R&D SERVICES	-0.0086	-0.0144	0.1681 **	0.1890 **	-0.1957 **	-0.1746 *
	(0.0820)	(0.0857)	(0.0809)	(0.0901)	(0.0882)	(0.0958)

*, **, *** signify significance at 90%, 95%, and 99% confidence
(Standard errors in parentheses)
MLOGIT = multinomial logit

[7] The multinomial logistic model combines SPEED and OTHER appropriability mechanisms.

Data Appendix

Table A1 Summary statistics for all available data

Variable	Mean	St. Dev.	Min	Max	N
R&D expenditures (Euros)	66705.4	191037.9	0	2356906	635
EMPLOYEES	12.9328	16.0398	1	100	774
EXPORTS	0.3760	0.4847	0	1	774
PRODUCT INNOVATION	0.2209	0.4151	0	1	774
PROCESS INNOVATION	0.0840	0.2775	0	1	774
BOTH INNOVATION	0.2119	0.4089	0	1	774
PARTNER	0.5090	0.5002	0	1	774
COOP HORZ	0.6745	0.4691	0	1	427
COOP VERT	0.5012	0.5006	0	1	427
DISCRETE	0.2132	0.4098	0	1	774
HIGH TECH	0.1061	0.3082	0	1	754
MED HIGH TECH	0.2732	0.4459	0	1	754
R&D SERVICES	0.2016	0.4015	0	1	754
PATENTS	0.2745	0.4466	0	1	674
SECRECY	0.1677	0.3738	0	1	674
SPEED	0.5579	0.4970	0	1	674

Table A2 Sample correlations

	R&D expenditures	EMPLOYEES	EXPORTS	PRODUCT INNOVATION	PROCESS INNOVATION	BOTH INNOVATION	PARTNER	COOP HORZ
EMPLOYEES	0.2483	1.0000						
EXPORTS	0.2981	0.2517	1.0000					
PROD INNOVATION	0.1456	0.0160	0.0786	1.0000				
PROC INNOVATION	0.0299	0.0004	-0.0444	-0.1867	1.0000			
BOTH INNOVATION	0.2167	0.0888	0.0838	-0.4606	-0.2056	1.0000		
PARTNER	-0.0991	-0.1473	-0.0898	0.0422	0.0000	-0.0610	1.0000	
COOP HORZ	0.1488	0.0844	0.1198	0.0441	-0.0235	0.1484	0.0203	1.0000
COOP VERT	0.1136	-0.0678	0.0646	0.0173	-0.0352	0.0608	-0.0128	0.1021
DISCRETE	-0.0329	0.1451	0.0323	-0.0955	0.1138	0.0983	-0.0269	0.0155
HIGH TECH	0.0188	0.0077	-0.0404	0.0946	0.0869	-0.1765	0.0821	0.0221
MED HIGH TECH	0.1771	0.1121	0.3176	0.1059	-0.0548	0.0898	-0.1125	0.0143
R&D SERVICES	0.1800	-0.0686	-0.1836	0.0429	-0.1025	0.0308	0.0497	-0.0007
PATENTS	0.0588	0.2005	0.1302	-0.0010	0.0125	0.0212	-0.0360	0.0549
SECRECY	-0.1253	-0.0125	-0.1417	-0.1148	0.1326	0.0153	-0.0087	-0.0887
SPEED	0.0319	-0.1131	0.0063	0.0885	-0.0703	-0.0836	0.0705	0.0294

	COOP VERT	DISCRETE	HIGH TECH	MED HIGH TECH	R&D SERVICES	PATENTS	SECRECY	SPEED
DISCRETE	-0.0431	1.0000						
HIGH TECH	-0.0249	-0.0964	1.0000					
MED HIGH TECH	-0.0530	-0.0365	-0.2655	1.0000				
R&D SERVICES	0.0680	-0.2661	-0.2594	-0.4085	1.0000			
PATENTS	0.0125	0.0844	-0.0258	0.0937	-0.0677	1.0000		
SECRECY	-0.1818	0.1046	0.0899	-0.0768	0.0279	-0.2705	1.0000	
SPEED	0.1221	-0.1317	-0.0430	-0.0240	0.0111	-0.6080	-0.4392	1.0000

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