

**PROTECTION MYOPIA: MANAGERIAL VIEWS TOWARDS
INTELLECTUAL PROPERTY AND THE IMPLICATIONS FOR
INNOVATIVE PERFORMANCE**

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Abstract. The strategies firms use to protect their intellectual assets can influence their ability to capture the benefits of their innovative efforts. Using models of distributed innovation processes and drawing from prospect theory, we explore the positive and negative aspects of legal appropriability. While claiming the benefits of a strategic orientation towards legal appropriability, we conjecture that protection myopia may also lead some firms to place too much importance on it. Examining a database of UK firms, we find that a strategic orientation towards legal appropriability is curvilinearly related to innovative performance. However, the negative effects of this myopia are moderated by collaboration breadth and by the ability to balance legal and informal protection.

Keywords. Appropriability, Intellectual property rights, Innovation, Innovative performance, Collaboration breadth, Balance between legal and informal protection.

The ability to appropriate or capture the benefits of an innovation is a central element in gaining and sustaining competitive advantage. Many innovators have been forced out of markets because of their inability to appropriate the benefits of their innovative efforts. Firms can use a variety of mechanisms to protect their innovations, ranging from patents to trade secrets. Accordingly, strategies for protecting knowledge have become a central part of the development of an innovative strategy (Rivette & Kline, 2000). Moreover, managerial appropriability strategies have been found to be an important source of performance heterogeneity (Colombo, 2003; Dushnitsky & Lenox, 2005; Teece, 2002).

This paper extends the literature on appropriability of innovation in three ways. Firstly, most theoretical and empirical research on appropriability has been focused at industry level, and targeted primarily at policy makers (Cohen *et al.*, 2000; Levin *et al.*, 1987). Here, we conduct a firm-level study of appropriability targeted at managers and management scholars. Secondly, where firm-level studies exist, they focus almost exclusively on patents as the method of appropriation (see for instance, Arora *et al.*, 2001; Ceccagnoli, 2009; Dushnitsky & Lenox, 2005; Rivette & Kline, 2000; Ziedonis, 2004). Yet, the empirical literature has shown that because innovations are typically complex and difficult to define completely and precisely, it is possible to invent around existing patent protections and, for firms that want to, do so successfully and fairly quickly (Mansfield *et al.*, 1981). Thus, there is a need for managers to think about appropriability methods that go further than patent protection (Ettlie & Reza, 1992; McGaughey, 2002; Teece, 1986). We deal with legal appropriability in its broad sense by looking at an array of legal appropriation mechanisms. Thirdly, a number of recent books on management have suggested that firms should increase the emphasis on formal intellectual property (IP) protection to release the “hidden value” of their intellectual capital investments (Rivette & Kline, 2000). While theoretically we maintain—and empirically substantiate—that a strategic orientation towards legal appropriability is imperative for innovation performance in terms of new product sales, we argue that too strong a focus on legal appropriability may produce negative returns. This is because a very strong focus can lead firms to turn away from interaction with other actors in the innovation system. Accordingly, and while drawing on models of distributed innovation processes and prospect theory, we advance the idea that firms may become too less or overly focused on protecting their innovations, and term the resulting state of the firm *protection myopia*.

Using statistical analysis based on data from a UK innovation survey, we investigate the relationship between a strategic orientation towards legal appropriability, and innovative performance. A Tobit model, estimated with instrumental variables to control for managers' self-selection of strategies, is used to explain innovative performance through firms' strategic orientation towards legal appropriability. A number of variables are controlled for, including research and development (R&D) and firm size. We find that a strategic orientation towards legal appropriability has a curvilinear (inverted U-shape) relationship to innovative performance. However, the negative consequence of this myopia is positively moderated by formal collaboration with a diverse set of partners on innovative activities. In addition, the relative weight attributed to informal protection moderates (dampens) the inverted U-shape.

THEORY AND HYPOTHESIS

Although capturing the benefits of innovations is difficult and for many innovators impossible, without the possibility that they may capture some of the benefits of their efforts, there would be little incentive for firms to innovate. Innovation does appear to have considerable benefits for those firms that are able to achieve these changes to their products and processes. Evidence shows that innovators achieve higher profits, greater market value, better credit ratings and have a stronger chance of surviving in the market (Cefis & Marsili, 2005; Czarnitzki & Kraft, 2004; Geroski *et al.*, 1993; Hall, 2000). This suggests that although innovators may only be able to partially appropriate the value of their innovations, many firms are able to reap rewards from their innovative efforts.

In order to capture the benefits of innovations, firms appear to rely on a bundle of different appropriability mechanisms, such as patents, design registrations and confidentiality agreements. However, no single mechanism can provide firms with security for their innovations (Arora,

1997; Cohen *et al.*, 2000). The combinations or bundles of appropriability mechanisms used by firms, make up what Cohen *et al.* (2000: 8) term an “appropriability strategy.” This suggests a considerable degree of managerial choice about whether and how to gain legal forms of appropriability and that such choices can be critical to overall enterprise performance (Pisano, 2006).

The decision of a firm to focus on legal appropriability is in part shaped by the distinctive features of the IP system itself. Although the cost of applying for a patent may be modest, the effort required to defend it can be high (Gowers, 2006: 38) and only a defensible patent has significant economic value (Sherry & Teece, 2004). Infringement is self-policing and, when an infringement is found, the court processes for a remedy are often slow, especially in the UK where—on average—resolution of legal disputes over IP takes four times longer than in Germany (Gowers, 2006: 116). Any legal remedy is likely to materialize only several years later. There is also a long delay from the date of filing a patent application to its formal recognition by a patent office; the average time for the European Patent Office (EPO) is 45.3 months (EPO, 2006: 22).

Given the above factors, for many firms formal IP protection is perceived to be too cumbersome, too slow and too ineffective to be worth devoting strategic resources towards. To some extent, this is reflected in the fact that most firms do not patent. It is also not uncommon for firms to lack even rudimentary knowledge about the organization and management of the formal IP protection system. For example, the Confederation of British Industry (CBI) found that more than 70 percent of all UK firms were unaware that patents from the UK Intellectual Property Office are subject to territorial restrictions (CBI cited in Gowers, 2006). In this paper, we focus on the impact of a strategic orientation towards appropriability mechanisms that

involve legal procedures and competencies, including patents, design registration, and confidentiality agreements; and on how such an orientation might shape the innovative performance of business firms.

Legal Appropriability Orientation as a Determinant of Innovative Performance

The starting point of this research is that a legal appropriability orientation is positively associated with innovative performance as long as it is not pursued too aggressively. According to the resource-based view of the firm, sustained competitive advantage may be achieved through control over resources that can be considered valuable, rare, non-substitutable, and imperfectly imitable (Barney, 1991). Product innovations may be considered resources that are valuable, rare and non-substitutable, but in many cases may be imitable. Teece (1986) demonstrates that when an innovator firm lacks complementary assets (such as competitive manufacturing, distribution channels and complementary technologies), weak IP protection will most often lead imitators or holders of complementary assets to profit from an innovation at the expense of the innovator. Accordingly, some firms choose to invest managerial resources and attention in legal appropriability by developing IP departments; using in-house or external legal experts; dedicating staff time to preparation, defense and enforcement of patents; and by implementing strict rules of disclosure.

Although focusing on legal appropriability is no guarantee of successful appropriation (Teece, 1986: 287), this approach may be considered a necessary condition for the appropriation of innovative rents. Such a focus allows the firm to increase barriers to entry to potential competitors or imitators, thereby isolating the firm in its market space. Such efforts may also allow the firm to increase the value of its existing assets by creating opportunities to enter the market for technology. Given the relatively limited use of formal IP protection in many

industries, firms that can successfully gain access to and exploit legal mechanisms may be able to utilize competitive mechanisms which other firms may be unable or unwilling to use.

Accordingly, those firms with an explicit orientation towards appropriating innovations are more likely to be able to capture the benefits of their innovations.

Nevertheless, too strong an orientation towards legal appropriability may have negative performance implications. When firms become too focused on appropriability, this may prevent them from engaging in essential formal and informal knowledge trading with external actors, given that this involves exchange, i.e. the provision of knowledge in order to be able to receive knowledge. Von Hippel (1988: 76-92) shows that many innovators have dense networks of relations with their suppliers, users, and competitors, and that strategic trading of certain ideas and secrets is often mutually beneficial. As Liebeskind (1997: 655) suggests, "...it may be undesirable to overly restrict knowledge-trading relationships with outsiders—even outsiders who can potentially appropriate valuable knowledge—because these same outsiders may possess knowledge that is highly valuable to the firm, and which would be costly or even impossible for the firm to replicate." Recent studies of innovators have suggested that many successful firms have moved away from tight appropriability and instead are adopting an "open" innovation model. Chesbrough (2003) suggests that innovators need to be cautious about becoming too closed to external actors and external opportunities. Indeed, Laursen and Salter (2006) demonstrate that openness to external sources can have positive effects on innovative performance. In Chesbrough's model of open innovation, firms draw ideas from a large number of external sources, and make some of their technology available to actors outside the firm, as a way of locating new pathways to commercialization. These studies suggest that firms whose appropriability strategies are too tight may be foregoing opportunities for exchange.

Why then, are some managers not able to find the right balance between external engagement and legal appropriability? The potential for managers to suffer from myopic behavior is well established in cognitive studies of managerial behavior (Schwenk, 1984; Walsh, 1995). In the case of legal appropriability, myopia may lead firms to underemphasize legal protection, resulting in them failing to adequately invest time and resources in building up their formal IP stocks and legal capabilities. In this area, managers may suffer from over-optimism about the value and merits of their innovative ideas, leading them to “exaggerate their control over events, and the importance of the skills and resources they possess in ensuring desirable outcomes.” (Kahneman & Lovallo, 1993: 27). This problem is likely to be especially pertinent to the case of the development of new products, as managers here have to make deep and irreversible commitments to something that’s eventual value in the market is uncertain. Such optimism can be a necessary requirement for mobilizing the organizational and human resources required to achieve an innovation—such as championing the idea with potential customers and collaborators (Howell & Higgins, 1990)—but can also lead managers to turn away from formal IP by assuming that such measures are burdensome and unnecessary in fast moving environments. This choice, however, can leave the firm at risk of being overcome by skilled imitators that are willing to bear the costs of engaging in the formal IP system.

In contrast, an overemphasis on legal appropriability may lead firms to enter a state, in which efforts to protect and control dominate the process of commercialization. Instead of focusing on the wide range of activities necessary to achieve innovation, managers may focus on too narrow a range of outcomes (Kahneman & Lovallo, 1993). In this case, managers fail to see that the innovation process is a journey requiring the orchestration of a broad range of external actors and actions, such as coordinating development efforts with customers and suppliers. By

failing to adopt a broad perspective, they may not fully appreciate the highly contingent nature of their innovation's economic value. Such an over-emphasis on legal protection may also reflect a profound fear of theft on the part of the innovator, which may lead managers to exercise "excessive vigilance" towards protection of their innovation efforts (Benartzi & Thaler, 1995: 87). To be sure, managers who are preoccupied with the legal protection of their innovative efforts are likely to shy away from exchanges with external parties, even when such exchanges may be beneficial. This is because their fear of loss is likely to be much greater than their expectation of future reward; a situation of myopic loss aversion that is common in decision making processes (Kahneman *et al.*, 1990). Myopic loss aversion will make managers more sensitive to potential losses, rather than potential gains. Indeed, research has shown that such individuals are liable to overestimate the losses over the gains of a decision by a factor of two, "...meaning the disutility of giving something up is twice as great as the utility of acquiring it." (Benartzi & Thaler, 1995: 74). Such an aggressive behavior with respect to legal protection may also be a strong signal to the environment that scares off potential external partners, lowering opportunities to the orchestration of complementary efforts on the part of others.

To characterize an under- or overemphasis on legal appropriability, we use the term *protection myopia* to capture the particular challenges related to the use of legal protection mechanisms. In sum, the above discussion leads us to conjecture that there are clear advantages in having a legal appropriability orientation for reaping the benefits of innovation, but that at some point, the focus becomes too strong, and the cost of appropriation begins to outweigh the benefits. Accordingly, we hypothesize that:

Hypothesis 1. A firm's strategic orientation towards legal appropriability is curvilinearly (taking an inverted U-shape) related to its innovative performance.

The benefits of formal collaborations for innovation—when executed appropriately—are well recognized in the literature (see for instance, Mowery *et al.*, 1996). However, formal collaboration may not only have direct performance implications; executing collaborative agreements on innovation related projects with a variety of external partners is also an indication that the participating firms have a more open outlook than those firms not relying on collaboration partners. This indicates that these firms have been able to partially overcome the protection myopia described above—both in terms of over- and under-emphasis on legal appropriability. We consider a strong and a weak emphasis on legal appropriability in turn.

Regarding a strong emphasis on legal appropriability, firms engaging in a range of innovation-related collaborations are less likely to suffer the negative consequences of a strong legal appropriability for at least two reasons. Firstly, firms whose formal collaborations span a diverse type of partners will have a strong incentive to build capabilities in the use of legal mechanisms of protection because external collaboration can increase the risks of knowledge leakage (Arora, 1995; Gans *et al.*, 2002). This argument suggests a complementary relationship between external collaboration and the level of formal IP protection as holding formal IP may facilitate the exchange of knowledge assets. From this point of view, having a very strong orientation towards appropriability will have more benefits when the firm is engaging in formal innovation collaboration with different external partners, as compared to the situation when the firm has no collaboration.¹ Secondly, the central theoretical idea of this paper—as expressed in the build-up to Hypothesis 1—builds on the idea that firms can become “closed” to other

¹ This “complements” logic does not, however, conflict with the scaring off logic described above, as it pertains to the *ex post* situation were the decision to collaborate has been made. By contrast, scaring off refers to the situation in which firms become scared of collaborating and exchanging knowledge more generally *ex ante*.

organizations in their approach to the innovation process as a result of too heavy a focus on protection, thereby foregoing opportunities for knowledge exchange. Accordingly, it can be derived from our theory that firms already having an open approach or strategy to use the external partners in their innovation processes should be expected to suffer less from myopic loss aversion and derived over-emphasis on legal protection. In other words, provided that firms already collaborate—and therefore by definition are not missing out on external engagement in the innovation process—we expect the performance penalty associated with very high levels of legal appropriability to be lower than for non-collaborative firms. In summary, for high values of firms' orientation towards legal appropriability, the associated downward bend of the inversely U-shaped relationship between innovation performance and the firms' orientation towards legal appropriability, will become less steep as the number of collaboration partners increases.

Firms engaging in a range of innovation-related collaborations are, however, not only less likely to suffer negative consequences of a strong emphasis on legal appropriability; they are also less likely to suffer negative consequences of a low investment in appropriability. This is because the formal collaboration experience with different types of partners enables firms to recognize the necessity of protecting their innovations and therefore lowers the dangers that firms will be myopic, and hence, over-optimistic about the potential gains arising from their innovation (Gans *et al.*, 2002; Heiman & Nickerson, 2004). Formal collaborative agreements related to innovation require knowledge of how to orchestrate a legal competence, either in-house and/or sourced externally (Ring, 2002). Experienced collaborators are likely to have built up routines and skills for operating in the “markets for technology”, enabling them to develop collaborative arrangements in areas where information is uncertain and incomplete (Arora *et al.*, 2001). In doing so, these firms are less likely to narrowly frame the innovation process. In

addition, the IP issues that arise when working with a range of collaboration partners may heighten the need to build capabilities in the use of different legal mechanisms. To be sure, each partner type may require the firm to give emphasis to different IP mechanisms as norms of knowledge exchange vary across communities of practice (Dasgupta & David, 1994). The range of external partner types in a firm's collaboration portfolio may, therefore, increase the scope and depth of the legal appropriability capabilities that an organization possesses, enhancing managerial awareness of IP issues in general. Therefore, the span of collaboration experience decreases the probability that a firm is uninformed of the possibilities for legally protecting its innovations successfully, and hence, makes under-protection much less likely.

Given the above arguments, we expect to observe few collaborative firms with very low values of orientation towards legal appropriability, and therefore we expect—for lower values of firms' orientation towards legal appropriability—a weaker relationship between firms' orientation towards legal appropriability and innovation performance, as the number of collaboration partner types increases. In other words, for low values of legal appropriability, the associated upward bend of the inversely U-shaped relationship between innovation performance and legal appropriability will be weaker, as the number of collaboration partners increases. In summary, we conjecture that innovation collaboration will affect both under- and overprotection:

Hypothesis 2. The relationship between strategic orientation towards appropriability and innovation performance is moderated by innovation collaboration breadth, so that the inversely U-shaped relationship becomes weaker with greater levels of collaboration.

The dangers of an under- or over-focus on legal appropriability in a firm's innovation strategy may be shaped by other elements of their appropriability strategy. As Cohen, Nelson and Walsh (2000) and Arundel (2001) demonstrate, a firm's appropriability strategy involves

informal as well as legal methods. Informal appropriability strategy includes mechanisms such as lead times or first mover advantages, secrecy, and the complexity of the product. Although the effectiveness of these different informal methods remains disputed (Hannah, 2005; Suarez & Lanzolla, 2007), it is clear that such methods often play a central role in a firm's overall innovation strategy. Research suggests that there can be complementarities between the use of legal and informal methods of protection. Legal and informal appropriability strategies may be combined successfully for a given innovation, when an innovation is comprised of separately protected components or features—firms often protect an innovation by applying for one or more patents while keeping other parts secret (Arora, 1997). Different appropriability mechanisms may also be used at different stages of the innovation process. Firms may initially rely on secrecy prior to the commercialization of a new product, but subsequently try to retain competitive advantage through formal means, such as patents and trademarks.

However—as demonstrated by Arundel (2001) — in developing an appropriability strategy, firms may have a tendency to favor one set of methods over another, partly because legal and informal methods differ so markedly in the managerial activities associated with each. Here, we posit that firms' relative weight between informal and legal methods in their overall appropriability strategy will moderate the relationship between legal appropriability orientation and innovation performance. In particular, we argue that a weak relative weight to informal appropriability over legal appropriability will accentuate the protection myopia both in terms of over- and under-protection. We suggest that the reason for this accentuation is that firms that are unable to combine their legal approach with informal methods will miss out on opportunities afforded to firms that balance their use of both approaches. For example, if a firm has a weak orientation towards legal appropriability but gives a strong relative weight to legal

appropriability over informal appropriability, this implies that the firm attributes little importance to appropriability overall—not only little importance to legal appropriability. This may be due to unrealistic expectations about the efficacy of the formal IP system. To be sure, the protection myopia may lead some firms to believe that just slight orientation towards legal appropriability may be sufficient to secure protection, leading to an underestimation of the managerial costs associated with the successful use of this strategy. Thus, the negative performance implications of a low level of strategic orientation towards legal appropriability is amplified by a weak focus on informal appropriability over legal methods in the firm's overall appropriability strategy.

There may also be additional negative performance effects in the case where a firm has a very strong orientation towards legal appropriability and gives little relative weight to informal appropriability over legal appropriability. We have previously argued that a very strong legal appropriability strategy could have negative performance implications because such an approach is a signal of excessive vigilance on the part of the firm toward potential losses from knowledge exchange with external parties. A heavy emphasis attached to legal appropriability in the firm's overall appropriability strategy may imply a very strong myopia in the direction of legal appropriability, while ignoring complementary informal protection. Thus,

Hypothesis 3. The relationship between strategic orientation towards appropriability and innovation performance is moderated by the relative weight attached to informal over legal protection in the firm's appropriability strategy, so that the inversely U-shaped relationship becomes weaker the more weight the firm gives to informal protection.

METHODS

Empirical Design and Sample

The data for the analysis are taken from the UK innovation survey, which is based on the Eurostat Community Innovation Survey (CIS) (Stockdale, 2002). The basic definitions and types of questions suitable for innovation surveys are documented in the Oslo Manual, developed by the Organisation for Economic Co-operation and Development (OECD, 2005). CIS data provide a powerful lens on innovation and its antecedents and consequences, complementing more common measures, such as patent statistics and product announcements (Ahuja & Lampert, 2001; Kochhar & Parthiban, 1996), and have been widely used in academic research. In this study, we use and extend the empirical literature that examines the determinants of the percentage of innovative sales (see, Cassiman & Veugelers, 2006; He & Wong, 2004; Laursen & Salter, 2006; Mairesse & Mohnen, 2002).

In the survey, product innovation is defined as: "...goods and services introduced to the market which are either new or significantly improved with respect to fundamental characteristics. The innovations should be based on the results of new technological developments, new combinations of existing technology or utilisation of other knowledge by your firm" (DTI, 2003). Firms were asked to ascribe shares of their sales to different types of innovations, such as innovations that are "new to the market" or "new to the firm." Alongside these performance questions are questions on appropriability issues, collaboration patterns, obstacles to innovation, sources of knowledge for innovation, R&D expenditure, and other innovation activities.

The creation of the sample and implementation of the survey was managed by the Office of National Statistics (ONS). The survey was sent to a total of 13,315 business units in the UK in

April 2001 and a follow-up mailing of 6,287 surveys was made in November 2001 to better capture regional differences. The questionnaire was sent to the person in the firm responsible for responding to official government surveys, commonly the Managing Director or Chief Finance Officer. They were asked to obtain information from the relevant departments inside their organizations. The sample was stratified by 12 Standard Industrial Classification (SIC) classes and covers the main sectors of the UK economy. The total response rate was 41.7 percent (Stockdale, 2002). The sample of manufacturing firms includes 3,413 firms. In the present study, we focus on manufacturing firms with past or current innovative activities of any kind (2,012 firms) and with non-missing values (1,943 firms).

The first best option for avoiding a non-response bias is to achieve a high response rate (Armstrong & Overton, 1977)—a 42 percent response rate is considered good. However, non-response biases were evaluated by comparing the industries represented in the sample with the whole population. The response rates for different industries, regions, and firm sizes are largely consistent with the overall response pattern (Stockdale, 2002). We also compared early respondents (first or “main” survey) with late respondents (regional top-up), following the procedure suggested by Armstrong and Overton (1977). The assumption made in this analysis is that late respondents—who are non-respondents in the early round—and non-respondents share similar characteristics and response biases. Accordingly, if there are no significant differences between early and late respondents, non-response bias is assumed to be uncritical. We used a chi-square test to establish whether the two subsamples differ regarding whether or not firms had carried out a product or process innovation over the period 1998-2000, and *t*-tests to compare the two sub-sample means with respect to key continuous variables, such as R&D intensity, firm size, and percentage of sales of innovative products, at four different levels of radicalness (see

Appendix Table 1). On the whole, we found no significant differences between early and late respondents. However, we did detect a significant difference on one case; the strategic orientation of firms towards legal appropriability seemed to be stronger in the top-up survey than in the main survey. In other words, firms that rely on legal appropriability mechanisms appeared to be less willing to respond to the questionnaire, i.e. more secretive. We think that inevitably more secretive firms would be less likely to respond, and therefore, we do not consider it a major limitation to the present study.

The CIS was extensively piloted and pre-tested in several European countries and firms from a variety of industrial sectors, before implementation (Smith, 2005). To avoid common method bias due to common scale anchors and formats, the questionnaire was constructed in such a way that respondents had to respond in different ways in various parts of the questionnaire. Accordingly, a mix of Likert scales, yes/no questions, percentages and questions pertaining to absolute numbers was employed in the questionnaire. In addition, however, we performed Harman's one-factor test on the items included in the models in this paper to examine whether common method bias might augment the relationships detected. Since we found multiple factors, and since the first factor did not account for the majority of the variance (the first factor accounts for 25 percent of the variance only), potential problems associated with common method bias were not indicated by the test (Podsakoff & Organ, 1986).

Measures and Econometric Method

Dependent and key independent variables. We employ four measures to indicate various types of firm-level innovative performance. Firstly, we use a variable that captures the ability of the firm to produce radical innovations—*innovations new to the market*. This variable is measured as the fraction of the firm's sales relating to products new to the market. In the UK innovation survey, firms were asked directly whether their enterprise “introduced any new or significantly improved products which were also new to the enterprise's market” and “what share of total firm [sales] these products accounted for in 2000” (DTI, 2003). We incorporated two variables as measures of incremental innovation, including a variable for the fraction of the firm's sales from product *innovations new to the firm* and a variable for the fraction of the firm's sales from *significant product improvements*. Finally, we included a variable that measures the percentage of total sales due to all types of product innovations (*all innovations*). Our sales weighted measure of innovation performance is consistent with Schumpeter's (1912/1934) view, since his notion of innovation not only pertains to the capacity to introduce “new combinations” in terms, for instance, of new products, but also to the commercial success of those products. In addition, the measure has been widely applied in the previous literature (Cassiman & Veugelers, 2006; He & Wong, 2004; Laursen & Salter, 2006; Mairesse & Mohnen, 2002), and some firms, such as 3M, use the percentage of innovative products to benchmark the commercial success of their innovative activities (Kanter *et al.*, 1997).

For determinants of innovative performance, we introduced a variable reflecting firm-level strategic orientation towards *legal appropriability*. The variable is constructed based on the question in the UK innovation survey about “the importance to your enterprise” during the period 1998-2000 of different methods for protecting innovations. We chose the three legal items

that are most directly aimed at protecting technological innovations, “patents”, “registration of design”, and “confidentiality agreements” from the survey. The three items are all measured on a 0-1-2-3 scale, with 0 representing “not used” to 3 representing a “high degree of importance.” The variable is obtained by factor analysis with Varimax rotation (factor loading for patents: 0.78; registration of design: 0.72; confidentiality agreements: 0.63; Eigenvalue: 1.53). The composite variable appears to have a high degree of statistical consistency (Cronbach’s Alpha = 0.78). Since our empirical model includes a squared term based on this variable, we normalized the variable by adding a constant, so that the minimum value of the variable becomes zero. The legal appropriability measure is constructed to capture the importance that managers place on these mechanisms for protecting their innovations, not the extent of their use. It appears that many firms use these mechanisms, but do not consider them important. Asking for information simply about the extent of use of different legal mechanisms would not provide a measure of their importance for the managers who use them. In this respect, the survey is consistent with the Yale and Carnegie Mellon surveys (see for instance, Arora & Ceccagnoli, 2006; Cohen & Levinthal, 1990; Cohen *et al.*, 2000; Levin *et al.*, 1987). The variable captures the outcome of firms’ appropriability strategies. Accordingly, we acknowledge the limits of our measure, since it is not a direct measure of intended or realized strategy. However, the list of legal appropriability mechanisms in the survey is exhaustive, and includes the central legal mechanisms mandated by law or by industrial custom, available to firms in the UK (Gowers, 2006).

A key (moderator) variable in our study is *collaboration breadth* (Laursen & Salter, 2006) with different types of external partners, based on the question “Did your enterprise have any cooperation arrangements on innovation activities with other enterprises or institutions in 1998-2000?” The respondents could chose from a list of six different types of collaboration partners

(suppliers, clients/customers, competitors, consultants/commercial labs/private research institutes, universities/other higher education institutes, and government research organizations). Innovation collaboration was defined to the respondents as “...active participation in joint innovation projects (including R&D) with other organizations.” The variable is calculated so that each firm gets a value of zero if they did not collaborate with any type of partner and the value of six if they collaborated with all the partner types (Cronbach’s alpha = 0.83). Another key moderator variable is the firms’ *relative weight on informal protection*. This variable is calculated as the sum of three measures of informal protection (secrecy; complexity and; lead time) divided by 3 minus the sum of three measures of legal protection (patents; registration of design and; confidentiality agreements) divided by 3. Since each of the six items included in this measure can take the values 0-1-2-3, the measure ranges from -3 to + 3. The variable is akin to Arundel’s (2001) variable that measures the relative importance of patents relative to secrecy.

Control variables.² To avoid obtaining a statistical artifact,² we include a number of control variables identified in the previous literature. *R&D intensity* is measured as firm R&D expenditure divided by firm sales, as a proxy for the level of the firm’s investments in the innovation process. The *user* variable was constructed based on a question in the survey about the importance of different sources of knowledge for innovation. Many studies have found that a key source of innovation is information-rich interaction with users. Accordingly, we included a

² We follow a two-stage approach by including external sources of innovation variables (for instance used by, Cassiman & Veugelers, 2006; Laursen & Salter, 2006) in the first stage of the model (an approach that is consistent with Cassiman & Veugelers (2006)). As a result, the external sources of innovation variables become strongly correlated with the predicted appropriability orientation variable, because, to a large extent, they contain the same variation. Given this, and because we do not have good alternative candidates for strong and valid instruments, we exclude the external sources variables in the second stage.

variable reflecting high-intensive utilization of user knowledge in innovation (von Hippel, 1988). This variable takes the value 1 if the firm indicates that it uses clients or customers as a source of knowledge for its innovation activities, to a high degree, and 0 otherwise.

We also controlled for *export intensity*, measured as firm export sales divided by total firm sales. The variable is a proxy for the degree to which the firm is exposed to international competition (Cassiman & Veugelers, 2006; He & Wong, 2004). In addition, *firm size* may influence the propensity to innovate. Although empirical research indicates that the advantages of size for innovative performance are ambiguous, size is commonly used as a variable in studies of innovative performance (Cohen, 1995). We measured firm size, expressed as a logarithm, by the number of employees. Following Cassiman and Veugelers (2006), we introduced measures of the *technological* and *market obstacles* facing the firm. These variables help capture the supply and demand factors that shape the potential for firm-level innovation (Cassiman & Veugelers, 2006: 74). Technological obstacles are measured by an item on the importance of a “lack of information on technology” and market obstacles are the average of responses to the items “lack of customer responsiveness to new goods and services”, “impact of regulations and standards” and “lack of information on markets” (Cronbach’s alpha = 0.75). As a high perceived level of obstacles can also be a function of high levels of opportunities in the external environment, we normalized the obstacles variables by 3-digit SIC industry averages. Finally, we included 13 industry controls to account for different levels of innovation intensities across industries (Cohen *et al.*, 2000; Levin *et al.*, 1987) and 12 geographical dummies to account for diversity in the ability to innovate across UK regions (Love & Roper, 2001).

Reliability of the dependent and key independent variables. Although we are unable to directly compare responses from two or more individuals from the same firm for the same

period, we had access to another wave of the survey data (CIS 4), covering the period 2002-2004. We utilized the overlapping sample to examine the reliability of our measures over time, or its test-retest reliability. This second survey employed a similar sampling frame with an almost identical set of questions. The response rate of the later survey was 58 percent, including 4,863 manufacturing firms (Robson & Ortman, 2006). The degree of overlap between the two samples is 431 firms. We found that despite that fact that few firms are able to be persistently innovative (Geroski *et al.*, 1997), all four innovation measures correlate across the two surveys at the $p > 0.001$ level and the correlation coefficients are 0.20 (*innovations new to the market*), 0.16 (*innovations new to the firm*), 0.29 (*significant product improvements*), and 0.40 (*all innovations*). For the variable measuring the orientation towards *legal appropriability*, we observe a strongly significant correlation coefficient of 0.55 between the two surveys. With respect to the two moderator variables measuring the *collaboration breadth* across different types of partners and *relative weight on informal protection*, the correlation coefficients are 0.29 and 0.28 respectively.

Econometric model. The dependent variable in the regression model is censored, since the variable is the percentage of innovative sales and, therefore, by definition, ranges between 0 and 100. Accordingly, a Tobit analysis was applied as the main vehicle of estimation (see Wooldridge, 2002: 517-549). However, we had an endogeneity problem, since we have to take account of the fact that management's expectations in relation to performance outcomes with respect to the strategy chosen, can lead to produce statistical artifacts in the form of biased coefficient estimates when using a single equation Tobit model, not correcting for endogeneity (Hamilton & Nickerson, 2003). These biases can result from omitted variables associated with management's self-selection, which affects both strategy choice and innovation performance (see

Wooldridge, 2002: 50-51). It is possible to diminish—if not remove—the endogeneity bias using an instrumental variable (IV) regression approach. In this context, we address the issue of obtaining consistent standard errors using the correction procedure suggested by Murphy and Topel (1985). For details of the instrumental variable procedure, see the Appendix.

RESULTS

Descriptive Results

Descriptive statistics and simple correlations are given in Table 1. The table shows that, among other things, on average, 4 percent of firms' sales can be attributed to products new to the world.

Insert Table 1 about here

Table 2 presents three of the legal appropriability methods listed in the survey of manufacturing firms. Among the legal mechanisms, confidentiality agreements are the most important; 48 percent of firms indicated that they found this method important for appropriation. Only 28 percent of firms indicated registration of designs as a method used for appropriation. If the importance of appropriability mechanisms across industries (not documented for reasons of space) is scrutinized, we find — in accordance with the literature (Levin *et al.*, 1987)—substantial differences, with chemical, and machinery & electrical product firms assigning high levels of importance to all legal appropriability mechanisms.

Insert Table 2 about here

Econometric Results

The estimations of the second-step structural Tobit model are presented in Table 3 (the estimations of the two first-step equations are reported in the Appendix). When looking at Model

I in Table 3, we find strong support for Hypothesis 1 stating that the strategic orientation towards legal appropriability is curvilinearly—taking an inverted U-shape—related to innovative performance, when innovation performance is measured as innovations new to the market. Firstly, the parameter for the orientation towards appropriability is significant and positive in explaining innovative performance. Accordingly, firms with a (stronger) orientation towards legal appropriability appear to have higher levels of innovative performance. Secondly, the negative parameter for the squared term is also significant, indicating that when firms become too focused on appropriability, negative returns set in. By differentiating, and setting the obtained derivative equal to 0, we obtain the top point of $-\beta_1/(2\beta_2)$, where β_1 is the parameter for the orientation towards legal appropriability, and β_2 is the parameter for the orientation towards legal appropriability squared. According to this calculation, the top point in the case of Model I in Table 3 is 1.1. Since the upper range of our predicted appropriability variable is 2.34—and since we have 196 firms above the top point—our model predicts negative returns for very high levels of orientation towards legal appropriability. This suggests that a very strong strategic orientation towards appropriability can be detrimental to innovative performance.

To check robustness, we ran the model using our alternative measures of innovative performance. Models V and VI in Table 4 show that the relationship between firms' orientation towards legal appropriability and their innovative performance, is curvilinear in the case of the two more incremental innovation measures—sales of innovations new to the firm, and sales of significantly improved products. In the model with all innovations, the same curvilinear relationship is present (Model VIII).

Insert Table 3 about here

Given that the literature has identified differences in the importance of appropriability mechanisms across industries (Cohen *et al.*, 2000; Levin *et al.*, 1987), we estimated the model separately for industries associated high and low appropriability levels (using a sample split at the median). We did this at both the 13-industry levels that we use as dummies in the regressions, and at the three digit industry code level (83 industries). We have reported the results using the 13-industry levels (in Table 4, models VIII and IX). In both cases, we observe the same inverted U-shape with similar (and significant) parameters. The inverted U-shape is slightly stronger for high than for low appropriability industries (but the results are not significantly different between the two models). As a further robustness check, we ran the analysis without the instrumental approach—i.e., not correcting for endogeneity concerns—and with the search breadth and depth variables introduced by Laursen and Salter (2006) included. The results from this analysis are consistent with the results reported here.

Insert Table 4 about here

To validate our findings, and to obtain quantitative support for our conjectures concerning the direction of the causality (our two-stage approach is consistent with the idea of the suggested causality, but is not in itself proof), we used the dependent variable from the later wave of the survey. The two samples combined yield 432 firms with non-missing values, present in both samples. Unfortunately, the Tobit model does not converge for individual types of innovation, but we ran the model for sales from all innovations. The resulting estimations are presented in model Table 4, Model X and are consistent with Hypothesis 1. We also estimated a model in which lagged innovative performance and lagged innovative performance squared are explaining firms' strategic orientation towards legal appropriability (not reported for reasons of space).

Here, the parameters for innovative performance turned out to be insignificant. Although this is short of proving Granger-causality, the results do indicate a one-way causality running from strategic orientation towards legal appropriability to innovative performance and not vice-versa. Overall, the results suggest that our measure has a degree of predictive validity.

From the above discussion, it can be concluded that firms' orientation towards legal appropriability is significantly related to innovation performance; however, the size of the effect needs to be analyzed. In order to calculate predicted effects, we set all industry and regional dummies to zero (i.e. using as the baseline "non-metallic minerals" and "London"—the industry and region with the lowest parameters in Model I). The dummies for innovation cooperation and user interaction were also set to zero, as the zeros in both variables represent the majority of the sample; the other variables were set to their sample averages. Since we are applying a Tobit model (with a "corner solution" interpretation), it is changes in the unconditional expected values, not linear predictions, that should be reported (for details, see Wooldridge, 2002: 523). Using this set-up, Model I, for instance, predicts that increasing the orientation towards a strategy of legal appropriability by half a standard deviation below the mean, to the mean, is associated with an increase in the sale of products new to the market by 53 percent. Increasing the orientation towards legal appropriability by half a standard deviation above the mean is associated with an increase in the sales of products new to the market by 34 percent (half a standard deviation plus the mean corresponds to 0.47 only). Increasing the orientation towards legal appropriability by half a standard deviation above the turning point of the curve (at the value 1.1) is associated with a decrease in the sales of products new to the market by 6 percent.

The proposition of Hypothesis 2 that the inverted U-shaped relationship between the strategic orientation towards appropriability and innovative performance is moderated by

innovation collaboration, such that the effects of under- and overprotection become less pronounced with innovation collaboration, is tested in Table 3, Models II and IV. The two models give support to this hypothesis. Innovation collaboration has significant moderating effects on both legal appropriability and legal appropriability squared. To clarify this complex interaction, we follow Schick and Ponemon (1993) in graphing (in Figure 1) the relationship between the dependent and key independent (main and squared) variables for low and high values of the moderator variable for the estimations found in Model IV. We plot the effects at the 10th percentile (no collaboration partners) and at the 90th percentile (two partner types). Again, we set the dummy for user interaction to zero while the other variables are set to their sample averages. Out of our total sample of 1,943 firms, there are 362 with formal innovation collaboration agreements. The graph shows that as expected, the curvature of the relationship is much less pronounced for firms with innovation collaboration, while the effect is very pronounced for firms without innovation collaboration activities. In fact, for collaborative firms, legal appropriability strategy plays little role in shaping innovative performance.

Insert Figure 1 about here

Hypothesis 3 states that the inverted U-shaped relationship between the strategic orientation towards appropriability and innovative performance is moderated by relative balance between informal and legal in the firm's overall appropriability strategy. This hypothesis is tested in Table 3, Model III and IV. The results (see Figure 2) indicate that the relationships is significantly moderated by the balance in overall appropriability strategy such that firms with a strong bias toward legal over informal methods have a more outspoken inverted U, whereas firms with a balance toward informal methods have a less outspoken inverted U. This suggests

that if a firm has a strong emphasis on legal over informal methods in its overall appropriability strategy, its level of orientation to legal appropriability is critical for its innovative performance. The orientation towards legal appropriability is less critical when firms give relative weight to informal protection over legal protection.

Insert Figure 2 about here

Among the control variables, the parameters for innovation cooperation breadth, R&D intensity and users are consistently positive and significant in explaining the proportion of sales of innovative products, whereas technological and market obstacles are generally not.

CONCLUSION AND DISCUSSION

Capturing the profits from innovative activities is difficult and many firms find the rents from their innovations are captured by their competitors, or by owners of specialized complementary assets. Our study adopted a firm-level approach, focusing on how managers' choices about how to appropriate innovations can shape the firm's ability to innovate and to capture the returns from these innovations. In doing so, we have helped to extend our understanding of how firms can proactively create their appropriability conditions by strategic action (Pisano, 2006). We found support for the idea that firms' strategic orientation towards legal appropriability is curvilinearly related to innovative performance. It appears that many firms allocate either too little or too much strategic orientation to legal appropriability, thereby entering a state we termed *protection myopia*. When we compare the number of firms that are either below or above the tipping point we find that by far the majority of firms appear to give too little emphasis to appropriability, while around ten percent of the firms are situated above the tipping point, suggesting that under-orientation is more widespread than over-orientation. This finding supports the conclusions

found in the Gowers Review (2006) affirming that a substantial number of managers underemphasize formal IP and that managers are often unaware of how the formal IP system works. In the case of too much focus on legal protection, our findings provide quantitative support for already existing qualitative evidence suggesting that many firms are unable to set their orientation towards legal appropriability appropriately (Gowers, 2006). This finding highlights the organizational challenges of putting in place an effective appropriability strategy and how these challenges are often underestimated by managers (Liebeskind, 1997). The results are also consistent across different degrees of product innovation radicalness, and for innovative performance measured across four to six years after an orientation towards legal appropriability was first observed.

With respect to the alleviating effect due to innovation collaboration, we found support for this hypothesis. Firms with broad innovation collaboration activities with different types of partners are much more likely to have found the right balance as regards the strategic orientation towards appropriability. For most collaborating firms, formal collaboration has a significant dampening effect on the negative effects of an under- and overemphasis on legal protection. This may be explained by the idea that firms successfully collaborating for innovation are likely to have developed highly refined mechanisms—including IP—for managing interactions with the external environment. However, an additional explanation for the very pronounced effect may be self-selection, implying that those firms with the best resources and capabilities are also those that collaborate.

Concerning the alleviating effect due to balance between informal and legal methods in the firms' overall appropriability strategy, we found that under- and overprotection becomes more prevalent if the firm has a strong relative focus on legal methods. This suggests that if a firm has

a low investment in legal appropriability and also does not emphasize informal appropriability, it is in grave danger of being overcome by rivals. However, if the firm invests heavily in legal appropriability and does not also emphasize informal appropriability, they are more likely to suffer from the protection myopia than a firm that has adopted a more balanced appropriability strategy. The results also suggest that legal appropriability works like a sharp knife: it can be very effective, but dangerous when yielded by the wrong hands (see Figure 2). In the case where firms attribute relatively little weight to informal over legal appropriability, the results seem to suggest that firms can perform in a superior fashion regarding innovation, but only when they are able to find the optimal level of legal appropriability. However, when firms are unable to find the optimal level of legal appropriability—giving either too little or too much weight to formal appropriability—they are better off having a strong balance towards informal appropriability. In other words, while legal appropriability is potentially very rewarding, firms have to be successful in getting the orientation towards legal appropriability right. If firms are unsure of their ability in this regard, they may be better off by giving a relatively strong emphasis to informal appropriability as such measures are likely to be easier to execute.

Implications for Theory

This study has theoretical implications for the resource-based perspective. According to this view, sustained competitive advantages may be attained through ownership of resources which can be considered valuable, rare, non-substitutable, and imperfectly imitable. In this paper, we have demonstrated that firms—to some extent—can influence the degree to which their resources are imperfectly imitable through their legal appropriability strategies. In addition, by focusing on firms' orientation towards appropriability, we have contributed to the literature on first mover advantages (Lieberman & Montgomery, 1998) in showing how the use of legal

protection methods may help to enable firms to capture rents through product innovation. More specifically, we have shown that being first as the result of a product innovation does not ensure market success—measured by high levels of innovative product sales; firms also appear to be required to have an orientation towards legal appropriability.

Our study suggests that limited strategic orientation on legal appropriability increases the likelihood that firms will be overtaken by skilled industrial rivals. In developing innovations, managers need to constantly monitor their external environment and make early decisions about what methods to employ to capture the returns from their firms' efforts. The present study indicates that many managers do not give sufficient attention to formal IP protection. One reason for this might be that formal IP protection systems are very inefficient (Jaffe & Lerner, 2004). In the UK and elsewhere, formal IP protection is expensive to acquire, difficult to defend, and time consuming to exploit, and many firms may simply lack the resources and capabilities necessary to reap the benefits from their "Rembrandts in the attic." Indeed, the ability to protect innovations may be a central dynamic capability for firms as they seek to capture returns from their knowledge and skills (Eisenhardt & Martin, 2000; Teece, 2007). The present research supports the notion that a firm's dynamic legal appropriability capabilities can be an important source of resource heterogeneity and that these variations can lead to variations in performance.

Implications for Practice

This study has important implications for managers. First, the consequences for innovative performance of giving little emphasis to appropriability are severe. Our results indicate that many managers give too little such emphasis—firms need to invest time and other resources in IP protection. Second, a very strong emphasis is almost equally damaging to innovative performance. The study of IP protection in management studies often assumes that "more is

better” (Rivette & Kline, 2000). However, here we found evidence consistent with the idea that an over-emphasis on legal appropriability can be detrimental to innovation performance, suggesting that such a simplistic philosophy will not bring success. Thus, exhortations that firms should acquire stronger IP protection may be harmful to innovative performance if pursued too aggressively, especially if a focus on IP protection leads firms to turn away from external interactions. The benefits of openness should not be compromised by an over-emphasis on legal appropriation. Third, this paper has demonstrated that managers need to balance their orientation towards legal appropriability with their emphasis on informal appropriability.

Limitations and Future Research

The current study is limited by the nature of the data available. Although our analysis builds on a large and multi-industry survey, it primarily focuses on data from one period, supplemented by information from a subsequent survey. In this paper, we have focused on how the strategic orientation of a firm towards legal appropriability shapes its innovative performance, but given the cross sectional nature of the data, it is possible the direction of causation could be reversed. Such a position would assert that more innovative firms need to use more appropriability mechanisms, while firms that are very innovative may be producing innovations so quickly that they do not need to rely on legal appropriability mechanisms. Although this interpretation is not implausible, there are reasons to suggest that the direction of causality works along the lines suggested in this paper rather than in the opposite direction. First, the Gowers Review (2006) attests that managers often underemphasize formal IP and that they are even unaware of how the formal IP systems in the UK and elsewhere are organized. Second, our two-stage approach is consistent with the idea of the suggested causality as strategic orientation towards legal appropriability is endogenously determined. Third, we have attempted to deal directly with the

causal relationship by lagging the key dependent variable by four years and have found some evidence to support our suggested direction of causality. However, the only way to settle the matter of causality finally, would be to obtain access to a panel data set with a significant time series dimension. Collecting information on appropriability strategies, however, remains a formidable task for researchers. The path-breaking research on appropriability has relied on surveys completed in 1982 (Yale) and 1994 (Carnegie Mellon). Our preliminary research, using two waves of a survey, suggests that strategic choices about legal appropriability might play an important role in shaping subsequent innovative performance, but this finding requires further empirical corroboration.

In this study we found that for most collaborating firms, formal collaboration has a dampening effect on the negative effects of an under- and overemphasis on legal protection. We suggested that this could be due to the fact that firms that have successfully collaborated for innovation are likely to have developed highly sophisticated mechanisms for managing interactions with the external environment and that an additional explanation for the very pronounced effect could be self-selection. Future research could attempt to disentangle this learning story over time.

Finally, our study raises the important issue of a fundamental tension that exists when managers seek to develop innovations—they need to work with external parties while at the same time protecting and exploiting what they know for commercial gain. We still need to know more about how managers should configure the internal and external elements of their firm over time in a bid to resolve the associated difficult conflicts.

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APPENDICES

APPENDIX TABLE 1. Early respondents compared with late respondents

Variable	Mean-early	Mean-late	Chi-square	p-value
Innovator yes/no			0.960	0.327
			<i>t</i> -value	
Innovations new to the market	4.03	3.60	0.680	0.497
Innovations new to the firm	7.08	6.94	0.187	0.852
Significant product improvement	6.57	7.10	-0.734	0.463
Legal appropriability	0.60	0.77	-4.116	0.000
R&D intensity	0.69	0.94	-1.284	0.199
Firm size	201.59	232.19	-1.287	0.198

Instrumental variables and endogeneity

It is possible to reduce, if not remove, endogeneity bias through an instrumental variables (IV) regression approach, since the chosen instruments must not be correlated with the unobserved variable representing manager's self-selection in the second stage model. Thus, apart from being correlated with the model's (endogenous) predicting variable, the instruments must not suffer from the same problem as the original predicting variable (Wooldridge, 2002: 105). This leaves, however, a problem in the selection and defense of suitable instruments. Here we exploit two types of instruments. First, we include two variables related to market structure; second, we include two variables to measure the extent to which the firms use particular organizations as sources of innovation, that are not related to the error process in the second stage. The variables are defined as the *minimum efficiency scale* variable, which is measured as the median plant size, expressed as an average for the years 1998-2000 (Sutton, 1998), and the *instability of within-industry market shares* over the averages of the years 1998-2000, using the measure suggested by Hymer & Pashigian (1962). These variables are based on the 3-digit SIC code, which includes 83 industries and covers the entire UK manufacturing sector. Data for these industry measures are taken from ONS register data, which includes the Annual Respondents Database and Business Enterprise Research and Development. The variables *competitors as sources* and *consultants as sources* of knowledge and information for innovation activities are based on the question in the survey enquiring about the importance of different sources of knowledge for innovation (measured on a 0-1-2-3 scale).

As required (see, Murray, 2006), all our instruments in the first-stage regression model correlate (see the Appendix Table) with the variable they instrument for (legal appropriability). Since we are using a Tobit-Tobit specification, we have no ideal test of the validity of the

instruments, because the Sargan over-identification test for all instruments requires the calculation of R-squared. Consequently, to gain some idea of the validity of the instruments, we revert to 2SLS estimation of our two equations, although, as pointed out above, this means of estimation could lead to biased coefficients. The joint null hypothesis is that the group of instruments are valid, that is, they are uncorrelated with the error term in the outcome equation, and that the excluded instruments are correctly excluded from the estimated equation. With the four aforementioned instruments the Sargan chi-squared test statistic is 1.6, with a corresponding *p*-value of 0.44 (calculated using the *ivreg2* module for Stata). In other words, we cannot reject the null hypothesis stating that our group of instruments are uncorrelated with error terms in the outcome equation. Since our estimations include an endogenous regressor that enters the outcome equation non-linearly (through the inclusion of a squared term), a number of problems emerge—see Davidson and MacKinnon (1993: 224-226). Davidson and MacKinnon suggest using powers of the original instruments—in our case the power of two—as the instruments for the non-linear term. We followed this approach. The Murphy-Topel (1985) correction procedure for obtaining consistent standard errors was implemented in Stata code by Hardin (2002) and this code was applied and modified in a Tobit-Tobit setting by Hansen, Mitchell, & Drope (2005). We use this Stata code in our estimations. The results of the estimation for the 1st stage of the procedure are reported in Appendix Table 2.

APPENDIX TABLE 2. Tobit 1st step regressions explaining strategic orientation towards legal appropriability, across UK manufacturing firms

	Legal appropriability	Legal appropriability squared
Minimum efficiency scale	0.32*** (0.05)	
Instability of within-industry market shares	3.60** (1.23)	
Using competitors as sources	0.38*** (0.04)	
Using consultants as sources	0.44*** (0.04)	
Minimum efficiency scale squared		0.11*** (0.02)
Instability of within-industry market shares squared		25.65** (8.59)
Using competitors as sources squared		0.26*** (0.03)
Using consultants as sources squared		0.34*** (0.04)
Constant	-2.18*** (0.26)	-2.99*** (0.33)
No. of obs	1943	1943
No. of left censored obs		
Log likelihood	-2336	-3153
Chi-square	373***	236***
ML (Cox-Snell) R2:	0.15	0.08
McFadden's pseudo R2	0.07	0.04

Robust standard errors. One-tailed tests: ** $p < .01$; *** $p < .001$

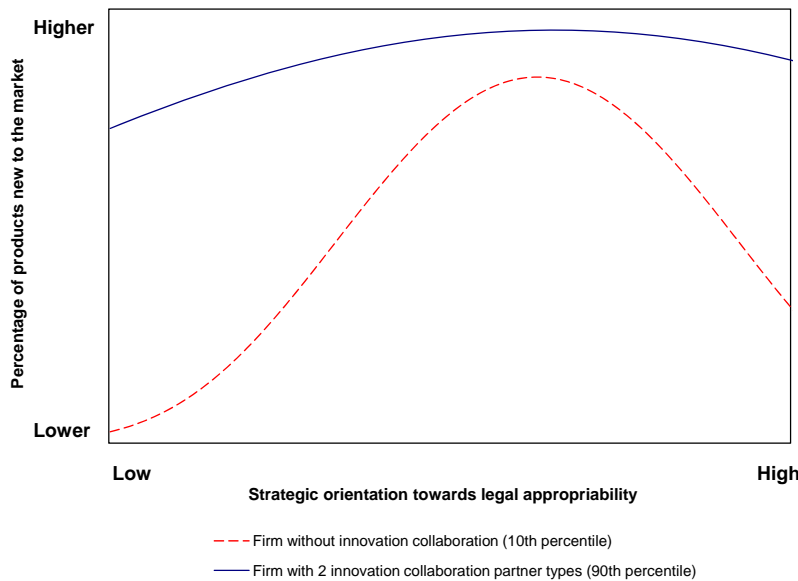


FIGURE 1. The effect of strategic orientation towards legal appropriability on innovation performance, moderated by innovation collaboration

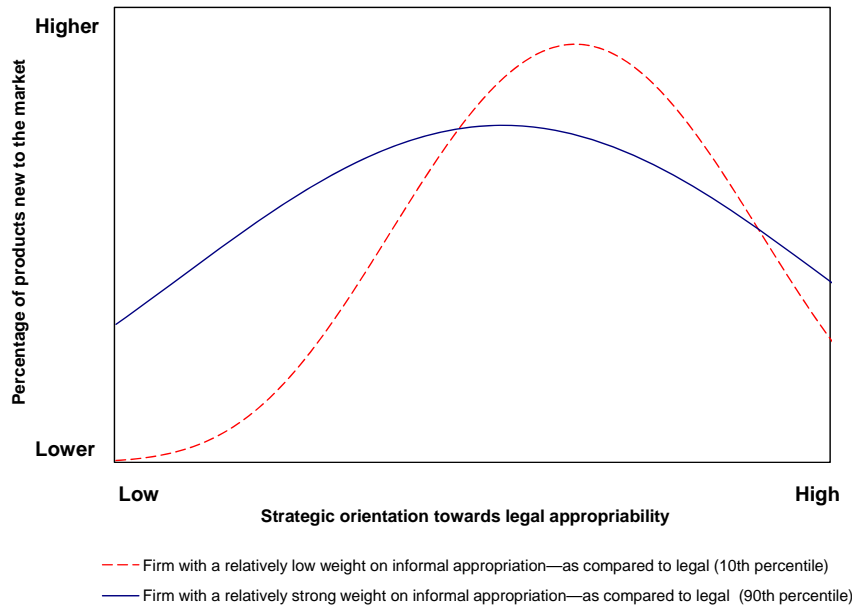


FIGURE 2. The effect of strategic orientation towards legal appropriability on innovation performance, moderated by the relative weight on informal appropriation

TABLE 1. Descriptive statistics and simple correlations^a

Variable	Mean	s.d.	Min.	Max.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Innovations new to the market	3.95	13.42	0.00	100.00												
2. Innovations new to the firm	7.03	16.20	0.00	100.00	0.43											
3. Significant product improvement	6.75	15.09	0.00	100.00	0.26	0.45										
4. All innovations	13.78	23.69	0.00	100.00	0.46	0.78	0.74									
5. Legal appropriability	0.67	0.86	0.00	2.75	0.10	0.63	0.76	0.22								
6. Innovation cooperation breadth	0.47	1.14	0.00	6.00	0.03	0.08	0.66	0.60	0.28							
7. Relative weight on informal protection	0.28	0.79	-3.00	3.00	0.06	0.06	0.07	0.09	-0.32	0.03						
8. R&D intensity	0.78	4.10	0.00	72.12	0.25	0.25	0.39	0.26	0.58	0.51	0.03					
9. User	0.18	0.39	0.00	1.00	0.24	0.00	0.33	0.53	0.70	0.86	0.10	0.04				
10. Export intensity	19.53	27.56	0.00	100.00	0.08	0.09	0.53	0.61	0.30	0.21	-0.01	0.76	0.83			
11. Firm size	4.29	1.43	0.00	9.47	-0.01	0.00	0.05	0.07	0.34	0.79	-0.06	0.06	0.07	0.24		
12. Technological obstacles	0.09	0.86	-1.60	2.44	-0.04	0.06	0.03	0.06	0.33	0.04	0.01	0.00	0.05	0.05	0.07	
13. Market obstacles	0.10	0.78	-1.53	2.25	0.05	0.07	0.04	0.07	0.68	0.03	0.06	0.02	0.21	0.01	0.06	0.57

^a $n = 1807$. □ indicates predicted variable from the first-step Tobit estimations. Correlations equal to or above |0.05| are significant at $p < 0.05$. Two-tailed tests.

TABLE 2. The importance given to different appropriability methods for innovation 1998-2000

Appropriability method	Not used	Low	Medium	High
	Percentages			
Patents	68	7	10	15
Registration of design	73	9	9	9
Confidentiality agreements	52	12	16	20
Average	64	9	12	15

TABLE 3. Tobit regressions explaining innovative performance, across UK manufacturing firms

Variables	I	II	III	IV
	Innovations new to the market	Innovations new to the market	Innovations new to the market	Innovations new to the market
Legal appropriability \square	18.75 *** (5.87)	26.24*** (6.54)	23.88 *** (6.17)	30.39 *** (6.72)
Legal appropriability squared \square	-8.66 ** (3.22)	-12.84*** (3.65)	-10.83 *** (3.30)	-14.50 *** (3.67)
Legal appropriability \square \times Innovation cooperation breadth		-12.39** (4.55)		-11.42 ** (4.56)
Legal appropriability squared \square \times Innovation cooperation breadth		6.06** (2.36)		5.66 ** (2.35)
Legal appropriability \square \times Relative weight on informal protection			-18.81 ** (7.24)	-17.12 ** (7.14)
Legal appropriability squared \square \times Relative weight on informal protection			7.85 * (3.68)	6.93 * (3.57)
Innovation cooperation breadth	3.75 *** (0.93)	7.59*** (1.71)	3.75 *** (0.92)	7.26 *** (1.72)
Relative weight on informal protection	2.80 * (1.46)	2.65* (1.45)	7.38 ** (2.48)	6.87 ** (2.47)
R&D intensity	1.27 *** (0.36)	1.28*** (0.34)	1.24 *** (0.34)	1.25 *** (0.33)
User	11.55 *** (3.29)	11.18*** (3.27)	11.68 *** (3.30)	11.35 *** (3.28)
Export intensity	0.07 [†] (0.05)	0.08* (0.05)	0.07 [†] (0.05)	0.08 [†] (0.05)
Firm size	0.26 (0.92)	0.30 (0.91)	0.16 (0.92)	0.20 (0.92)
Technological obstacles	-1.36 (1.71)	-1.64 (1.68)	-1.25 (1.69)	-1.52 (1.67)
Market obstacles	0.78 (1.95)	1.00 (1.94)	0.65 (1.94)	0.84 (1.93)
Constant	-62.18 *** (12.07)	-63.94*** (12.15)	-62.02 *** (12.04)	-63.62 *** (12.09)
Industry dummies (13)	Yes	Yes	Yes	Yes
Geography dummies (12)	Yes	Yes	Yes	Yes
No. of obs	1943	1943	1943	1943
No. of left censored obs	1542	1542	1542	1542
Log likelihood	-2522	-2518	-2517	-2514
Chi-square	174 ***	182***	184 ***	190 ***
ML (Cox-Snell) R2:	0.06	0.06	0.06	0.07
McFadden's pseudo R2	0.03	0.03	0.04	0.04

\square Indicates predicted variables from the first-step Tobit estimations. Murphy-Topel corrected standard errors in model II and III. Robust standard errors. One-tailed tests: [†] $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

TABLE 4. Tobit regressions explaining innovative performance

Variables	V	VI	VII	VIII	IX	X
	Innovations new to the firm	Significant product Improvements	All innovations	Innovations new to the market, high appropriability industries	Innovations new to the market, low appropriability industries	All innovations, $t+4$ (2004)♣
Legal appropriability \square	12.85 ** (4.35)	21.39 *** (5.08)	25.01 *** (5.44)	21.83 *** (7.13)	14.39 * (8.29)	19.77 * (8.59)
Legal appropriability squared \square	-3.40 \dagger (2.29)	-7.88 *** (2.60)	-7.83 ** (2.78)	-9.22 ** (3.68)	-5.54 \dagger (3.97)	-8.57 * (4.06)
Innovation cooperation breadth	1.91 *** (0.62)	3.54 *** (0.77)		2.89 ** (1.24)	4.57 *** (1.29)	5.37 *** (1.29)
Relative weight on informal protection	1.74 * (1.02)	3.90 *** (1.26)		2.78 \dagger (1.95)	2.62 \dagger (1.96)	4.26 \dagger (3.28)
R&D intensity	1.17 *** (0.23)	0.61 * (0.27)	1.05 ** (0.37)	1.14 *** (0.37)	2.90 *** (0.60)	1.36 * (0.73)
User	4.90 * (2.27)	7.41 ** (2.55)	9.03 *** (2.74)	7.17 \dagger (4.43)	15.73 *** (4.22)	13.27 ** (4.98)
Export intensity	0.05 \dagger (0.04)	0.09 ** (0.04)		-0.04 (0.06)	0.26 *** (0.07)	0.01 (0.10)
Firm size	0.77 (0.65)	2.57 *** (0.75)	1.19 \dagger (0.83)	0.55 (1.31)	0.74 (1.18)	-0.06 (2.32)
Technological obstacles	0.37 (1.20)	0.52 (1.43)		-4.81 * (2.42)	2.76 \dagger (2.11)	3.44 (3.71)
Market obstacles	3.33 ** (1.38)	0.39 (1.62)		3.71 \dagger (2.86)	-4.16 * (2.53)	5.64 \dagger (4.35)
Constant	-44.96 *** (8.20)	-54.90 *** (9.46)	-69.34 *** (10.18)	-52.44 *** (10.66)	-70.13 *** (12.66)	-48.38 ** (19.97)
Industry dummies (13)	Yes	Yes	Yes	Yes	Yes	Yes
Geography dummies (12)	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	1907	1907	1907	929	1014	432
No. of left censored obs	1193	1331	1083	688	854	224
Log likelihood	-4023	-3414	-4807	-1489	-1007	-1181
Chi-square	251 ***	243 ***	329 ***	75 ***	118 ***	112 ***
ML (Cox-Snell) R2:	0.07	0.08	0.12	0.05	0.12	0.17
McFadden's pseudo R2	0.03	0.03	0.03	0.02	0.06	0.05

\square Indicates predicted variables from the first-step Tobit estimations. LEGALAPPB \square is the broad legal appropriability strategy involving five underlying legal appropriability items. Robust and Murphy-Topel corrected standard errors. One-tailed tests: $\dagger p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$. ♣ All explanatory variables, except legal appropriability, are also observed for 2004.