External Sources of Knowledge, Governance Mode, and R&D Performance
Carl F. Fey and Julian Birkinshaw
Journal of Management 2005; 31; 597
DOI: 10.1177/0149206304272346

The online version of this article can be found at:
http://jom.sagepub.com/cgi/content/abstract/31/4/597
External Sources of Knowledge, Governance Mode, and R&D Performance†

Carl F. Fey*
Institute of International Business, Stockholm School of Economics,
P.O. Box 6501, S-11383 Stockholm, Sweden,
and Stockholm School of Economics in Russia

Julian Birkinshaw
London Business School, Sussex Place, Regents Park, London NW1 4SA, England

This article examines how the choice of governance mode for external R&D, along with openness to new ideas and codifiability of knowledge, affects R&D performance. Superior R&D performance is therefore viewed as arising through (a) the choice of approaches used by the firm to access knowledge from outside (university partnering, alliance partnering, and contracting), (b) the knowledge context of the firm (its openness to new ideas and the codifiability of its knowledge assets), and (c) the interactions between these two sets of factors. These arguments are tested, and mostly supported, using data on the R&D activities of 107 large firms based in the United Kingdom and Sweden.

Keywords: knowledge; research and development; external sourcing

The purpose of this article is to use a knowledge perspective to examine how the choice of governance mode for external transacting of research and development (R&D) activities affects R&D performance. We examine three approaches used by R&D organizations to...
source knowledge from the business environment (contracting, alliances with other firms, and partnering with universities), and we explore the particular conditions (in terms of how codifiable the knowledge is and the extent to which the firm is open to new ideas) under which they result in high R&D performance.

In addressing these issues, we build on two bodies of literature. One is the knowledge-based view of the firm (KBV) and its focus on the conditions under which certain types of knowledge assets can generate superior firm performance (e.g., Boisot, 1998; Grant, 1996; Hedlund, 1994; Kogut & Zander, 1992; Nonaka, Takeuchi, & Umemoto, 1996; Teece, Pisano, & Shuen, 1997). The other is the open systems perspective on organizations, in which the nature of resource exchange between the focal organization and its task environment affects the way the organization is structured and how it performs (Emery & Trist, 1965; Perrow, 1970; Thompson, 1967). We combine insights from both these bodies of literature to conceptualize the boundary of the firm as a semipermeable membrane through which knowledge flows at different rates and to different degrees (Kogut & Zander, 1992), depending on the governance form used and the knowledge characteristics. We argue that the development of distinctive and valuable knowledge assets is a function of the relative inflows and outflows of knowledge across its boundary. Inflows of knowledge from the environment augment the firm’s knowledge assets, but at the same time, outflows of knowledge (e.g., to competitors) erode their distinctiveness. The relative level of inflows and outflows is therefore a function of two factors: (a) the nature of the knowledge assets in question—specifically the ease with which they can be protected from imitation (Teece & Pisano, 1994), and (b) the firm’s chosen knowledge sourcing strategy, that is, the various boundary-spanning activities in which the firm chooses to engage.

We also suggest that social capital theory (e.g., Burt, 1992; Nahapiet & Ghoshal, 1998) can help explain which sourcing strategies are likely to result in the focal firm obtaining the most knowledge. Thus, the ability of the firm to achieve superior performance with the help of its knowledge assets is determined both by the nature of its knowledge assets and by its strategy for accessing external knowledge. This argument is developed and tested using data from 107 large firms located in the United Kingdom and Sweden.

Theory and Hypothesis Development

The Resource-Based and Knowledge-Based Views of the Firm

The resource-based view of the firm (RBV) has arguably become the dominant theoretical perspective in strategic management. In contrast to industrial organization (IO)—based models of the firm in which competitive advantage emanates from the strategic position adopted vis-à-vis the threats and opportunities in the business environment, the RBV starts with an analysis of the internal resources and capabilities of the firm and argues that under certain conditions, they can be the basis of competitive advantage. During the past decade, a large body of literature has emerged that elaborates this basic logic, and in particular, the characteristics that resources and capabilities need to have to form the basis of competitive advantage (Amit &
Schoemaker, 1993; Barney, 1991; Conner, 1991; Dierickx & Cool, 1989; Peteraf, 1993). Resources (also called assets) are defined as stocks of available factors that are owned or controlled by the firm... and are converted into final products or services by using a wide range of other firm assets. Capabilities refer to a firm’s capacity to deploy resources, usually in combination, using organizational processes to effect a desired end. (Amit & Schoemaker, 1993: 35)

Thus, it becomes apparent that resources are for the most part tradable through factor markets and are in general unlikely to be a source of competitive advantage, although an exception to this is cases where the resource can be legally protected (e.g., patents). Capabilities, on the other hand, develop slowly over time and are often causally ambiguous and socially complex, making them much more likely to meet the criteria of rarity and inimitability that are likely to lead to superior firm performance (Dierickx & Cool, 1989).

A distinct but strongly related body of literature focuses on knowledge as the most important strategic resource of the firm and the implications of this for the firm’s existence, its size and scope, and its ability to generate competitive advantage (Conner & Prahalad, 1996; Grant, 1996; Kogut & Zander, 1992; Spender, 1996). The KBV cannot as yet be viewed as a theory of the firm (Grant, 1996: 110), but it has attracted a great deal of interest in recent years and, to some degree, has supplanted the RBV as a focus for research. As Conner and Prahalad argued, “A knowledge-based view is the essence of the resource based perspective... Privately held knowledge is a basic source of advantage in competition” (1996: 477).

Despite the broad acceptance of the notion that knowledge is central to a firm’s competitiveness, there is still a great deal of discussion about the nature of knowledge and the way that it manifests itself within the firm. A useful starting point is to focus on the firm’s knowledge assets as the “building blocks” of the firm (Amit & Schoemaker, 1993). Knowledge assets include such intangible resources as reputation, a customer database, a new technology, or a consulting company’s service offering. As the earlier discussion indicated, knowledge assets can in principle be traded and therefore would not be expected to form the basis of a firm’s ability to achieve superior performance except in combination with certain higher order capabilities. However, the reality is that the market for knowledge assets is far from perfect, and the ability of the firm to appropriate value from them depends on several factors.

One primary factor is the ease with which knowledge assets are transferred across organization boundaries—through interfirm learning, exchange, or competitive imitation. Some knowledge assets are highly context-specific, tacit in nature, and hard to value, which makes it difficult for competitors to identify, copy, and use them; others are less tacit (relatively transparent and easily codified) and therefore easier for other firms to gain access to (Arrow, 1971, 1984; Grant, 1996; Kogut & Zander, 1992; Winter, 1987). A second issue is the extent to which intellectual property rights can be established around them, with patents and trademarks as the obvious examples of knowledge assets that are well protected. Taken together, these factors determine the “appropriability regime” for the knowledge assets in question (Teece & Pisano, 1994), or, in other words, the likelihood that the firm will be able to appropriate value from them.
We adopt an open-systems perspective (Emery & Trist, 1965; Perrow, 1970; Thompson, 1967) to conceptualize the organizational boundary of the firm as a semipermeable membrane through which knowledge passes at different rates and to different degrees. Inflows of knowledge from the environment augment the knowledge assets of the firm, and over time, those assets become more distinctive and valuable. Inflows of new knowledge also increase the possibility of novel combinations of knowledge, which can result in new technologies and products (Schumpeter, 1934). At the same time, outflows of knowledge from the firm to other actors (competitors, suppliers, customers) lead to competitive imitation and reduce the distinctiveness of the firm’s knowledge assets. The ability of the firm to obtain superior performance (proxied here in terms of the long-term effectiveness of R&D in creating breakthrough technologies and products) from its knowledge assets is therefore a function of the relative rates of inflow and outflow of valuable knowledge across the boundary of the firm.

**Accessing External Sources of Knowledge in R&D Organizations**

The empirical setting for this research is the R&D organizations of large firms and their approaches to accessing external sources of knowledge. This setting was chosen because R&D organizations rely—to a greater degree than most—on new sources of knowledge on an ongoing basis. Because innovation occurs primarily through new combinations of resources, ideas, and technologies, a fertile R&D environment relies on a constant inflow of knowledge from other places. Moreover, there are also reasons to believe that the need for access to external sources of knowledge is on the rise (e.g., Chiesa & Manzini, 1998; Haour, 1992; Narula & Hagedoorn, 1999). Most end products embody an increasingly broad set of technologies (e.g., electronics in cars), each of which requires highly specialized capabilities to develop, so firms can no longer hope to do everything in-house (Iansiti, 1997). Some industries (e.g., computers) have increasingly moved to open technological standards, easing the transfer of useful knowledge across firm boundaries. Furthermore, the financial pressure on R&D budgets has persuaded many firms that they can get access to basic research in universities far more cost-efficiently than they can do it themselves (Leonard-Barton, 1995: 144). By one account, on average, external sources account for between 34% and 65% of the inputs important to the development of successful innovations (Conway, 1995).

The focus in this article, in other words, is on the specific relationship between the mode of governance used in accessing R&D knowledge and R&D performance. The boundary between the focal R&D organization and the various partner companies in its environment is conceptualized as a semipermeable membrane, meaning that knowledge flows through it to varying degrees and at different rates (cf. Kogut & Zander, 1992, 1996). The permeability of the boundary is dependent on the type of knowledge in question. Some knowledge is relatively more codified, observable, and system independent, which allows it to move more freely across firm boundaries as well as within the firm (Kogut & Zander, 1992; Winter, 1987).

However, permeability is also dependent on the nature of the relationships that the R&D organization has with external actors—its strategy for gaining access to external sources of knowledge. Every firm has ongoing exchange relationships with customers, suppliers, and
many other actors in its task environment, and the way that these relationships are structured will have a considerable impact on the ease with which knowledge flows into and out of the firm. For example, a onetime transaction with a customer will allow little inflow or outflow of knowledge, whereas a long-term partnership with a university will—by design—encourage each party to learn from the other. The point is that the permeability of the firm boundary is to some degree a matter of strategic choice—in the way that external relationships are structured—and not just a function of the nature of the firm’s knowledge assets. And these choices, consequently, have implications for the ability of the firm to achieve superior performance based on its knowledge assets. This line of thinking becomes particularly salient as we move into an analysis of the different modes of governance by which R&D organizations gain access to external knowledge because each approach has very different implications for the flow of knowledge into and out of the organization.

What are the options for accessing knowledge from external sources? There is a large and diverse body of literature addressing this issue in the context of R&D organizations, but it is possible to identify two primary modes of governance—partnering and contracting (Veugelers & Cassiman, 1999).

Partnering is the development of knowledge through relationships with specific partner firms. Such relationships include university collaborations (Bailetti & Callahan, 1992; Conway, 1995), joint ventures and alliances (Hamel, 1991; Inkpen, 1992; Kogut, 1988; Mowery, Oxley, & Silverman, 1996), consortia of competitors (Chiesa & Manzini, 1998; Hagedoorn, 1993; Ingham & Mothe, 1998), and suppliers and customers (Håkanson & Johanson, 1992; von Hippel, 1988). Our study focuses on R&D partnerships. R&D partnering typically involves deep interaction between the parties during a protracted period of time, and as such, it tends to result in the development of relatively context-specific and tacit knowledge. When it works well, partnering is typified by a process of mutual learning and adaptation (Hamel, 1991; Inkpen, 1992; Lane & Lubatkin, 1998). Partnering can take a variety of forms, but in the context of this study, we are interested particularly in two forms—partnering with universities and partnering with other firms in alliances (including research consortia, joint ventures, and strategic alliances) to undertake R&D development. Interview respondents in the pilot study saw these as the most important and distinct forms of partnering in R&D.

Contracting refers to the acquisitions of knowledge on a market basis (Granstrand, Bohlin, Oskarsson, & Sjoberg, 1992; Haour, 1992; Mangematin & Nesta, 1999; Ulset, 1996). Examples include an auto manufacturer contracting out the development work on its new engine or a pharmaceutical company outsourcing its clinical trials. It also includes technology that is licensed from a second party (Atuahene-Gima, 1992). The benefits of contracting are several, including managing capacity problems, speed, gaining access to new areas of knowledge, and sharing of costs (Haour, 1992). However, it is also qualitatively different from partnering because the contracting firm is concerned primarily with the knowledge output of the contractee rather than the process of developing that knowledge in the first place. As such, it rarely gives the contracting firm full access to, or control over, the knowledge asset in question. For example, if an auto manufacturer contracts out engine development, it hands over primary responsibility for that activity to its contractee, and its internal capability to develop engines will typically atrophy.
Hypothesis Development

What is the impact of these two different modes of governance on the capacity of the R&D organization to access external knowledge and thereby to improve its performance? Social capital theory provides some important insights into these issues. Social capital theory was originally applied in community studies to describe relational resources embedded in personal ties in a community. However, it has now been applied in many intraorganizational and interorganizational studies (e.g., Burt, 1992; Lee, Lee, & Pennings, 2001; Nahapiet & Ghoshal, 1998; Pennings & Harianto, 1992; Uzzi, 1997; Yli-Renko, Autio, & Sapienza, 2001). The theory highlights the importance for firms to develop external networks to create value (Lee et al., 2001), and more important, it also helps to understand the type of external relationships that are likely to create the most value.

Social capital theory asserts that the amount of knowledge the focal firm will obtain from its partner firm depends on three key characteristics of social capital in the relationship: social interaction, relationship quality, and partner network ties. Social interaction refers to the extent of informal exchange between two entities (Larson, 1992; Nahapiet & Ghoshal, 1998). Relationship quality represents the extent to which a good relationship atmosphere is developed on the basis of trust and reciprocity (Dyer & Singh, 1998; Ring & Van de Ven, 1992). Finally, partner network ties indicate the extent to which the focal firm obtains access to a wider network of firms through its partner firm (McEvily & Zaheer, 1999; Uzzi, 1997).

Consider the differences between partnering and contracting in terms of these three characteristics. When R&D is contracted out, the work is done by another firm, and thus less interaction is needed than is the case of partnering because by definition, partnering involves two firms working jointly on a project. Repeated interactions in the case of partnering provide the opportunity for relationship quality to be increased in terms of developing trust and interaction. And, because of the closer contact that is more likely to occur in partnering than in contracting, the focal firm is more likely to gain access to the partner firm’s network of contacts than in contracting. Thus, we can see that social capital theory predicts more learning is likely to occur through partnering than through contracting.

The earlier theoretical discussions about knowledge flows also provide some important insights. Partnering relationships can be expected to result in high levels of knowledge inflow and outflow—indeed, they are typically established for that purpose. The firm can expect to develop an understanding of its partner’s work practices as well as specific skills, technologies, or capabilities that it has access to within the scope of the relationship. However, the reverse is equally likely—that the partner organization will develop a detailed understanding of the firm’s skills and capabilities. In terms of the relative levels of learning by the two partners, there are a number of factors at work including their absorptive capacity, their learning intent, and the investment they make in the relationship (Cohen & Levinthal, 1990; Hamel, 1991; Inkpen, 1992; Lane & Lubatkin, 1998). But the critical issue is the relative inflows and outflows of knowledge to the focal firm, and here the story is complicated by the fact that when knowledge is shared, it is not lost per se; it merely loses its uniqueness vis-à-vis its original owner (Arrow, 1984). In other words, the relationship could result in large knowledge flows in both directions, but the net result would be that both ultimately benefited more from the
knowledge they gained than what they lost in giving the other access to their knowledge (i.e.,
knowledge sharing is not a zero-sum game). The above suggests that the consequences of part-
nering in terms of net knowledge flows are likely to be positive. The knowledge gained can
then be used to adapt or extend the firm’s existing knowledge assets, or it can help in the pursuit
of novel combinations of resources (Schumpeter, 1934), which will increase the likelihood of
new products or technologies for the firm. Two important types of partnering are partnering via
alliances with other firms and partnering with universities. Thus, we hypothesize the following:

Hypothesis 1: The higher the level of partnering with universities, the higher the firm’s R&D
performance.

Hypothesis 2: The higher the level of partnering with alliance partners, the higher the firm’s R&D
performance.

It is worth considering briefly the differences between universities and alliance partners.
One is that alliance partners are often competitors (broadly defined), whereas universities are
not, so there will be more out-of-bounds areas of knowledge in the former. A second is that
universities are more likely to share freely in a partnership than alliance partners because the
norms of scientific research emphasize sharing knowledge rather than hoarding it. The above-
mentioned differences suggest that university partnerships are more likely to yield meaningful
knowledge inflows. Thus, although we expect both types of partnering to be beneficial for
R&D performance, we can expect partnering with universities to result in superior R&D per-
formance compared with partnering with other firms via alliances.

Contracting also involves a two-directional flow of knowledge between the firms in the
relationship, but as social capital theory suggests, the net effect for the focal firm is likely to be
negative because the outflow will typically exceed the inflow. Let us consider this argument in
more detail. Contracting involves purchasing a service or technology in the marketplace rather
than developing it in-house (Haour, 1992; Quinn, 1992). This approach has a number of
important consequences. First, the firm will typically lose the capability to develop the service
or technology in-house because the key personnel will either move to the contractee or be rede-
ployed elsewhere. Second, the firm will typically give the contractee access to knowledge
about related activities so that it can perform its work effectively, and this interaction opens it
up to further knowledge losses. And, finally, contractees typically work with many client
firms, which essentially means that they provide a conduit for knowledge to flow from the
focal firm to its competitors. This will—all else equal—lead to a convergence between the
technologies of the firm and its competitors and will thus compromise the distinctiveness of
the firm’s knowledge assets. Counteracting these effects, we would expect contracting to
result in some knowledge inflows, such as increased expertise at working with external con-
tractors or knowledge about the contractee’s way of working. Because these effects will be
very small in comparison with the outflow of knowledge, the net effect is likely to be a strong
outflow of knowledge, which will reduce the distinctiveness of the R&D organization’s
knowledge assets and ultimately reduce its R&D performance.

Hypothesis 3: The greater the use of external contracting, the lower the R&D performance.
Three additional points should be made about the various approaches that are used to access external knowledge. First, there is widespread agreement in the literature that the different approaches are complementary, with firms doing in-house R&D alongside external partnering and contracting outperforming those doing one or the other (Gambardella, 1992; Haour, 1992; Rothwell, 1992; Ulset, 1996; Veugelers & Cassiman, 1999). Second, the focus of most empirical research is on the factors affecting the decision to use partnering or contracting, rather than the ultimate effect on the performance of the R&D organization. Kessler, Bierly, and Gopalakrishnan (2000) are a notable exception; they found that external contracting has a negative impact on R&D project performance. Finally, it is worth acknowledging that the firm can also access knowledge from the business environment in a number of other ways in addition to the two specific approaches mentioned above (e.g., hiring employees from competitors, business intelligence systems). However, in this article, we limit our focus to these two main methods of contracting and partnering.

The Knowledge Context of the Firm

The firm’s strategy for gaining access to external knowledge through partnering and/or contracting is important, but so is the broader organizational context of the firm because it shapes the attitudes and behaviors of people toward knowledge acquisition and development. We therefore consider two additional variables in depth: a culture of openness to new ideas and the tacitness of the firm’s knowledge assets. Both of these are seen as potentially having a direct effect on the firm’s R&D performance, as well as moderating the impact of partnering and contracting on performance.

Consider openness to new ideas first. This construct refers to a collective state of mind shared by organization members that encourages experimentation with different approaches, regardless of their origin. The argument that openness to new ideas will enhance R&D performance builds on a dominant logic (Prahalad & Bettis, 1986) or industry recipe (Spender, 1989) perspective, whereby the greater the level of conformity and allegiance to traditional ways of thinking, the more difficult it is for individuals in the firm to accept new or challenging ideas from the outside. To be clear, there is enormous value to the firm in having a strong dominant logic, especially in terms of the speed of decision making, the efficiency of internal processes, and the level of social cohesion in the firm; however, at the same time, this dominant logic creates a tight constraint around the ability of individuals in the firm to gain access to, and make use of, external knowledge. Thus, if the objective is to develop new technologies and ideas, a greater openness to new ideas (and a correspondingly weaker dominant logic) is preferable.

Hypothesis 4: The greater the openness to new ideas in the firm, the higher the R&D performance.

As well as directly affecting R&D performance, we would also expect openness to new ideas to enhance the effectiveness of partnering and contracting as modes of governance through which new knowledge is brought into the firm. The argument here is that openness to new ideas is a facilitating mechanism that improves the ability of individuals to make use of new knowledge when they find themselves interacting with external parties, whether through
contracting, partnering with universities, or partnering through alliances. In contrast, if a firm is not very open to new ideas, even the best R&D that the firm gains access to through its partnering or contracting will not have much impact on performance. Thus, we arrive at the following hypotheses:

**Hypothesis 5:** The more open to new knowledge a firm is, the more positive will be the relationship between partnering with universities and R&D performance.

**Hypothesis 6:** The more open to new knowledge a firm is, the more positive will be the relationship between partnering with alliance partners and R&D performance.

**Hypothesis 7:** The more open to new knowledge a firm is, the more positive will be the relationship between contracting and R&D performance.

The second firm-level factor is the **codifiability of the firm’s knowledge assets**. Although many approaches to categorizing knowledge have been put forward, our preference is to use the well-established distinction between codified and tacit knowledge, or, more accurately, the idea that all knowledge assets are codifiable to varying degrees. Simply stated, when the firm’s knowledge assets are relatively tacit, they are more difficult for competitors to understand and imitate; they are transferred less easily; and, as a result, their distinctiveness is eroded relatively slowly (Kogut & Zander, 1992; Teece & Pisano, 1994). All else being equal, the above suggests that the higher the degree of codifiability (lower tacitness) is, the lower a firm’s R&D performance is likely to be.

**Hypothesis 8:** The more codifiable the firm’s knowledge assets, the lower the R&D performance.

It is important to mention that another important factor affecting a firm’s ability to obtain superior firm performance is the extent to which its knowledge assets can be protected through intellectual property rights. In other words, even if knowledge assets are easily codified, they can still contribute to superior firm performance if they have patent protection. Intellectual property rights are not neglected in this article—they are included as a control variable.

Codifiability of knowledge assets is also hypothesized to have a moderating influence on the relationship between mode of governance and R&D performance. Both partnering and contracting (to different degrees) involve opening up the boundary of the firm to competitive scrutiny and imitation. However, if the firm’s knowledge assets are relatively less codifiable (more tacit), the risks of competitive imitation are much less than if they exist in a codified or observable form. As such, a less codifiable set of knowledge assets will reduce the outflow of knowledge through contracting and partnering, thereby making each approach slightly more favorable to overall R&D performance. Thus, we suggest the following three hypotheses dealing with codifiability of knowledge:

**Hypothesis 9:** The less codifiable the firm’s knowledge assets, the more positive will be the relationship between partnering with universities and R&D performance.

**Hypothesis 10:** The less codifiable the firm’s knowledge assets, the more positive will be the relationship between partnering with alliance partners and R&D performance.

**Hypothesis 11:** The less codifiable the firm’s knowledge assets, the more positive will be the relationship between contracting and R&D performance.
The hypotheses are summarized in the conceptual model presented in Figure 1.

**Method**

This research was conducted primarily through a mail questionnaire that yielded 107 responses from R&D-intensive firms in Sweden and Great Britain. In addition, there was an extensive pilot study involving interviews and a pretest of the questionnaire. Some secondary performance data were also collected on the responding firms.

**Pilot Study**

We conducted more than 50 detailed interviews with R&D managers in five firms (ABB, Ericsson, HP, Pharmacia, and Xerox). The purpose of these interviews was to understand R&D management in large firms, including such issues as the use of external sources of knowledge, the development of competitive advantage through R&D, and internal resource allocation systems. Toward the end of the pilot study, we put together the questionnaire using a combination of existing measures and new measures that addressed the specific issues that arose during the interviews. This questionnaire was administered to those individuals we interviewed, and on the basis of their feedback and an analysis of their responses, we amended the questionnaire.

**Sample Selection**

The sampling frame for the study consisted of R&D-performing industrial firms in Sweden and Great Britain. The choice of Sweden and Great Britain was made primarily for practical reasons. However, both countries invest a relatively high amount in R&D—3.85% and 1.83% of GDP, respectively, which places them ranked first and eighth in the world in terms of R&D spending (IMD, 2003). The findings should therefore be of interest to, and broadly comparable to, other developed economies. In Sweden, we assembled a database of R&D-intensive firms using the sources *Hugin* (owned by the magazine *Veckans Affärer*) and the Swedish Institute of Statistical Information’s (SCB) database. Foreign-owned firms were excluded from this database, as were holding companies. The questionnaire was sent to 160 companies. In Great Britain, we used the *Financial Times* list of the largest 500 R&D-intensive firms in the country, which, after removing foreign-owned companies, resulted in a database of 220 firms. In both countries, we telephoned each of these firms to get the name of the R&D director. The questionnaire was then mailed to that individual. We undertook a follow-up mailing 3 weeks later (Dillman, 1978). This procedure yielded a total of 52 responding firms in Sweden (32% response rate) and 55 responding firms in Great Britain (25% response rate). These response rates are not as high as we would have liked, but they are higher than average for international mail surveys (Harzing, 2000). Table 1 provides a breakdown of the sample by country. It indicates that the sample companies in the two countries are of similar age, R&D intensity, and overall performance. However, the British companies were on average some-
what larger and less international. In terms of sectoral distribution, the sampling methodology resulted in a variety of different R&D-intensive industries in the two countries. We checked the primary characteristics of the sample companies against those that did not respond to the
questionnaire in terms of overall size and industry sector. This check indicated that the Swedish sample was somewhat smaller than the group of nonresponding companies, but no other material differences were uncovered.

Variables

The constructs were operationalized through an iterative process, using insights from both the case studies and the extant literature. This section describes how constructs were measured on the questionnaire. Scales were constructed using unit weights for the items and taking the average of the items in a given scale.

Partnering. Exploratory interviews suggested that for the firm as a whole, there were typically a number of ongoing partner relationships at any point in time. As a result, we decided to focus on the perceived value of those partners as sources of R&D expertise. We used five questions, three relating to universities and two relating to alliance and joint venture (JV) partners. Factor analysis confirmed that these items split into two constructs as one would expect. Exact wording is as follows.

Partnering with universities. How valuable are the following as sources of R&D expertise:
(a) universities located close to the R&D sites, (b) universities located elsewhere in the same country, (c) universities located in other countries? (1 = not important, 7 = extremely important; Cronbach’s $\alpha = .79$). Some readers may be concerned at first glance that this question captures both a dimension of the importance of different geographic sources of R&D and the importance of universities as a source of R&D. We chose this wording because we thought R&D managers would be able to relate to these categories and because we wanted to cover the full scope of geographic options they faced. The high correlation between items, as well as the similar means and standard deviations for each question ($M$ Item 1 = 4.05, $SD$ Item 1 = 1.60; $M$ Item 2 = 4.38, $SD$ Item 2 = 1.65; $M$ Item 3 = 4.02, $SD$ Item 3 = 1.73), suggests that universities

<table>
<thead>
<tr>
<th>Mean</th>
<th>Sweden</th>
<th>England</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales (in £000) 1997</td>
<td>680,502</td>
<td>3,154,810</td>
</tr>
<tr>
<td>Year formed</td>
<td>1942</td>
<td>1946</td>
</tr>
<tr>
<td>R&amp;D % of sales 1997</td>
<td>11%</td>
<td>13%</td>
</tr>
<tr>
<td>Foreign sales 1997</td>
<td>71%</td>
<td>51%</td>
</tr>
<tr>
<td>ROE 1997</td>
<td>17%</td>
<td>14%</td>
</tr>
<tr>
<td>Major industries represented in sample</td>
<td>Pulp, paper, paper products 22%</td>
<td>Chemicals, chemical products 32%</td>
</tr>
<tr>
<td></td>
<td>Electric, telecom, medical 22%</td>
<td>Electricity, gas, water 15%</td>
</tr>
<tr>
<td></td>
<td>Chemical, chemical products 14%</td>
<td>Food, beverages, etc. 10%</td>
</tr>
<tr>
<td></td>
<td>Machinery and equipment 11%</td>
<td>Transport equipment 10%</td>
</tr>
<tr>
<td>Number of firms in the sample</td>
<td>52</td>
<td>55</td>
</tr>
</tbody>
</table>

Note: ROE = return on equity.
located in different geographic settings make a similar-sized contribution to the focal firm. Thus, we decided to group these items together in one construct.

Partnering with alliance/JV partners. How valuable are the following as sources of R&D expertise: (a) alliance or JV partners in the same country, (b) alliance or JV partners in other countries? (1 = not important, 7 = extremely important; Cronbach’s $\alpha = .81$). It is worth noting that in addition to having a high alpha, the means and standard deviations of the items making up this construct are very similar ($M$ Item 1 = 4.01, $SD = 2.04$; $M$ Item 2 = 4.09, $SD = 1.89$). Thus, in our sample, it seems that alliances both in the same country and abroad make a similar contribution to firm R&D.

Contracting. The important issue here was the extent of contracting in the firm, which our pilot interviews suggested could be measured as a simple percentage. Thus, we used a single direct question: What percentage of the firm’s technology capability is bought or insourced from other companies? Many firms contract only a small percentage of their technology development. As a result, because this variable was not normally distributed, we rescaled it on a scale of 1 to 5.

Openness to new ideas. Respondents were asked to respond to the following statements: Please indicate the extent to which you agree with the following statements about your company: (a) In this company, there is a great openness to picking up ideas from outside. (b) The “not invented here” syndrome is a real problem in our company (reverse coded) (1 = totally disagree, 7 = totally agree; Cronbach’s $\alpha = .73$).

Codifiability of knowledge. To measure the extent to which a firm’s knowledge assets were codifiable, as opposed to tacit, we used questions developed by Zander and Kogut (1995) and Zander (1991). Specific wording was as follows. Indicate on a scale of 1 to 7, where 1 = totally disagree and 7 = totally agree, the extent to which you agree with the following statements about your company: (a) New R&D personnel can easily learn their job by studying a complete set of blueprints, (b) new R&D personnel can easily learn their job by talking to experienced personnel, (c) educating and training R&D personnel is a quick and easy job, (d) a competitor can easily learn how to manufacture our product by studying the employees at work. The whole scale was reversed. Cronbach’s alpha was .72.

R&D performance. In considering R&D performance, it is common to distinguish between short-run “efficiency” measures (such as on-time and on-budget innovation projects) and long-run “effectiveness” measures (such as technological breakthroughs). In this article, because we are concerned with the distinctiveness of the R&D organization’s knowledge assets, it was appropriate to focus on measures of R&D effectiveness. Accordingly, we developed a three-item scale based on reviews of prior work and our interviews with the five pilot-study companies. The questionnaire items were as follows: Please rate your firm’s overall performance during the past 3 years, in comparison with competitor firms in the industry, in terms of (a) getting new products to market quickly, (b) coming up with radical/breakthrough tech-
nologies, and (c) bringing breakthrough technologies to market \(1 = \text{much worse than average}, 7 = \text{much better than average}; \) Cronbach’s \(\alpha = .75\).

**Control variables.** We included several control variables in our study. *Firm size* was measured as the overall sales revenue of the firm in 1997, expressed in pounds sterling. *Country* was a dummy variable, where Great Britain = 1 and Sweden = 0.

To help control for potential industry effects, we measured the extent to which market demand for the firm’s business was growing rapidly \(1 = \text{not characteristic at all of our industry}, 7 = \text{extremely characteristic}\) and also for the extent of a high rate of technological change in the industry \(1 = \text{not characteristic at all of our industry}, 7 = \text{extremely characteristic}\). These items are approximate proxies for Dess and Beard’s (1984) industry characteristics of munificence and dynamism. Dess and Beard (1984) identified munificence and dynamism as two of the most important characteristics that differentiate industries. Munificence is the extent to which an environment is able to support growth (Starbuck, 1976). Dynamism is the extent to which an environment is undergoing unpredictable change.

We also included the ratio of R&D expenditure to sales as a control \((R&D/sales)\), which has been suggested to differ by industry. Finally, we also developed a measure of the extent to which *intellectual property rights* existed in the firm’s industry. This is an important factor in the appropriability of knowledge assets because industries with strong intellectual property right regimes (e.g., pharmaceuticals) have to worry far less about codifying their assets than those with weak intellectual property right regimes (e.g., software). However, we decided not to include this as a primary construct in our analysis because it should be measured at the industry level. Following Winter (1987), we measured this variable using respondents’ perceptions. The exact wording of the statements was as follows. Indicate the extent to which these statements are characteristic of your industry: (a) We frequently monitor the patents of our key competitors, (b) it is important to patent our core technologies \(1 = \text{not characteristic at all}, 7 = \text{extremely characteristic}; \) Cronbach’s \(\alpha = .80\).

**Addressing Common Method Bias**

One potential weakness with the data is that both dependent and independent variables were measured using interview responses. We guarded against this threat by using Harman’s one-factor test to examine the extent of common method bias in our data (Podsakoff & Organ, 1986). A principal components factor analysis reveals there are four factors with an eigenvalue greater than 1 that together account for 67% of the total variance. The presence of several distinct factors combined with the relatively low amount of variance explained by the first factor (only 21%) indicates that the data do not suffer from common method variance (Podsakoff & Organ, 1986).

**Results**

Table 2 presents the means, standard deviations, alphas, and bivariate correlations between the variables used in the regression models. None of the independent variables are correlated
with each other at more than $p = .31$. Thus, multicollinearity does not seem to be a large problem. Table 3 shows the results of the regressions on R&D performance. The hypotheses were tested using standard ordinary least squares (OLS) regression techniques. Model 1 includes only the control variables, and Model 2 includes the control variables and the main effects. Interaction terms were created in the usual way by multiplying the relevant variables together. These interaction terms were centered to reduce any potential multicollinearity problems (Aiken & West, 1991; Jaccard, Turrisi, & Choi, 1990). We then ran two separate regression models, which included interaction terms, one with the openness-to-new-ideas interaction terms, control variables, and main effects (Model 3) and the other with the tacitness-of-knowledge interaction terms, control variables, and main effects (Model 4). We also tested the models by adding the squares of the main variables to ensure that we were not picking up spurious correlations in the interaction terms (e.g., Aiken & West, 1991; Ganzach, 1998), but these squared terms were not significant. As described above, we tested the controls in Model 1, we added the main effects to Model 2, and we added the interaction terms to Models 3 and 4. Following this order, below we present the results for control variables, followed by the results for the main effect hypotheses (Hypotheses 1, 2, 3, 4, and 8) and the results relating to our interaction hypotheses (Hypotheses 5, 6, 7, 9, 10, and 11).

Several control variables are significantly related to R&D performance. Parent firm country was significantly negatively associated with R&D performance in all of our regression models. This result indicates that U.K. firms report somewhat better R&D performance than their Swedish counterparts. Industry market demand and industry technological change were not significant in any of the models. R&D expenditure divided by sales was negatively associated with R&D performance and significant in Model 3. The extent to which knowledge could be protected by intellectual property rights was significant in all models, indicating that the extent to which one can protect R&D know-how with patents positively affects R&D performance. The final control, firm size, was not significant in any of the models.

Hypothesis 1, stating that partnering with universities is positively related to R&D performance, is supported in Model 2. Hypothesis 2, stating that partnering with firms via alliances is positively related to R&D performance, is not supported as it is nonsignificant in all of the models. Hypothesis 3, stating that the use of external contracting is negatively related to R&D performance, is significantly supported in all of our regression models. The fourth hypothesis, that openness to new ideas is positively related to R&D performance, is strongly supported as it is highly significant in all models. Hypothesis 8, that codifiability of knowledge is negatively related to R&D performance, also receives good support as it is significant in all models in which it is present (Models 2, 3, and 4).

Model 2, which includes our controls and main effect variables, has an $R^2$ of .427 ($F = 4.139, p < .001$), indicating that the model explains about 43% of the variance in R&D performance, which is quite acceptable. Model 2 (the model with the main effects and controls) explains about 25% more of the variance than Model 1 (the model with only the controls). This increase in amount of variance explained is significant as indicated by the change in $R^2$ having an $F$ of 5.500, $p < .001$. Model 3, which includes all items from Model 2 plus the interaction terms between mode and openness to new ideas, explains 50% of the variance ($R^2 = .496, F = 4.079, p < .001$). Furthermore, Model 3 explains significantly more variance than Model 2, providing support for the importance of the openness-to-new-ideas interaction terms. Simi-
### Table 2
Pearson Correlation Coefficients (N = 107)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (sales in £ million)</td>
<td>1.930</td>
<td>5.780</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country (United Kingdom = 1, Sweden = 0)</td>
<td>0.49</td>
<td>0.50</td>
<td>0.22*</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intellectual property rights</td>
<td>4.66</td>
<td>1.84</td>
<td>0.07</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D/sales</td>
<td>0.12</td>
<td>0.22</td>
<td>-0.08</td>
<td>0.05</td>
<td>0.16</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry market demand</td>
<td>4.25</td>
<td>1.51</td>
<td>-0.16</td>
<td>0.07</td>
<td>-0.035</td>
<td>0.28**</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry tech change</td>
<td>4.40</td>
<td>1.63</td>
<td>-0.02</td>
<td>0.03</td>
<td>0.20*</td>
<td>0.26</td>
<td>0.25**</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracting</td>
<td>3.53</td>
<td>0.91</td>
<td>0.07</td>
<td>-0.01</td>
<td>-0.17</td>
<td>0.13</td>
<td>-0.09</td>
<td>-0.17</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University partnering</td>
<td>4.15</td>
<td>1.35</td>
<td>-0.19</td>
<td>-0.14</td>
<td>0.24**</td>
<td>0.03</td>
<td>-0.07</td>
<td>-0.07*</td>
<td>-0.03</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alliance/JV partnering</td>
<td>4.05</td>
<td>1.75</td>
<td>-0.06</td>
<td>-0.21*</td>
<td>0.03</td>
<td>-0.09</td>
<td>0.20</td>
<td>0.20*</td>
<td>0.07</td>
<td>0.31**</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openness to new ideas</td>
<td>4.72</td>
<td>1.18</td>
<td>0.22</td>
<td>-0.14</td>
<td>0.17</td>
<td>0.28*</td>
<td>0.28**</td>
<td>0.28**</td>
<td>0.11</td>
<td>0.09</td>
<td>0.29**</td>
<td>0.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge codifiability</td>
<td>2.62</td>
<td>0.80</td>
<td>0.06</td>
<td>-0.03</td>
<td>-0.07</td>
<td>-0.06</td>
<td>-1.14</td>
<td>-1.14</td>
<td>-0.06</td>
<td>-0.13</td>
<td>-1.17</td>
<td>0.12</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>R&amp;D performance</td>
<td>4.38</td>
<td>1.28</td>
<td>-0.09</td>
<td>-0.19</td>
<td>0.31**</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>-0.24*</td>
<td>0.15</td>
<td>0.03</td>
<td>0.39**</td>
<td>0.20</td>
<td>0.75</td>
</tr>
<tr>
<td>Return on equity 1997</td>
<td>28.6</td>
<td>90.6</td>
<td>0.01</td>
<td>-0.18</td>
<td>0.06</td>
<td>-0.25*</td>
<td>0.06</td>
<td>0.06</td>
<td>-0.46**</td>
<td>-0.11</td>
<td>0.16</td>
<td>-0.08</td>
<td>0.04</td>
<td>0.30**</td>
</tr>
</tbody>
</table>

* Cronbach’s alphas are listed for the variables on the matrix diagonal when appropriate. NA = not applicable in cases where a Cronbach’s alpha was not appropriate to calculate because of the use of a single-item measure or similar. JV = joint venture.

* *p < .05.
** *p < .01
Model 4, which includes all items from Model 2 plus the interaction terms between mode of governance and codifiability, explains 52% of the variance ($R^2 = .521$, $F = 3.814$, $p < .001$). Furthermore, Model 4 explains significantly more variance than Model 2, providing support for the importance of the codifiability interaction terms.

### Analysis of Interaction Effects

To help provide a clearer understanding of the implications of the interaction terms for R&D performance in our regression models, we graph the significant interactions in Figures 2 and 3. Figure 2 shows how the relationship between partnering with universities and R&D performance changes with different levels of openness to new ideas.

### Table 3

**OLS Regression Results: Predictors of R&D Performance**

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>4.21***</td>
<td>4.16***</td>
<td>2.86***</td>
<td>4.65****</td>
</tr>
<tr>
<td>Parent firm country</td>
<td>.69*</td>
<td>.54*</td>
<td>.52*</td>
<td>.50*</td>
</tr>
<tr>
<td>Size (sales)</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Intellectual property rights</td>
<td>.20*</td>
<td>.12*</td>
<td>.15*</td>
<td>.12*</td>
</tr>
<tr>
<td>R&amp;D/sales</td>
<td>-.10</td>
<td>-.50</td>
<td>-.10*</td>
<td>-.60</td>
</tr>
<tr>
<td>Industry market demand</td>
<td>.07</td>
<td>.03</td>
<td>.09</td>
<td>.03</td>
</tr>
<tr>
<td>Industry technological change</td>
<td>-.13</td>
<td>-.11</td>
<td>-.12</td>
<td>-.07</td>
</tr>
<tr>
<td>Openness to new ideas</td>
<td>.41***</td>
<td>.29*</td>
<td>.43***</td>
<td>.11</td>
</tr>
<tr>
<td>Knowledge codifiability</td>
<td>-.28*</td>
<td>-.39*</td>
<td>-.31*</td>
<td>.15</td>
</tr>
<tr>
<td>External contracting</td>
<td>-.29*</td>
<td>-.34*</td>
<td>-.32*</td>
<td>.15</td>
</tr>
<tr>
<td>Alliance partnering</td>
<td>-.11</td>
<td>-.13</td>
<td>-.09</td>
<td>-.43</td>
</tr>
<tr>
<td>University partnering</td>
<td>.19*</td>
<td>.06</td>
<td>.15</td>
<td>.41</td>
</tr>
<tr>
<td>Contracting × Openness to New Ideas</td>
<td>.01</td>
<td>.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University Partnering × Openness to New Ideas</td>
<td>.10**</td>
<td>.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alliance Partnering × Openness to New Ideas</td>
<td>-.04</td>
<td>.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracting × Codifiability</td>
<td>-.11*</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University Partnering × Codifiability</td>
<td>.07</td>
<td>.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alliance Partnering × Codifiability</td>
<td>.06</td>
<td>.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$R^2$ .169 .427 .496 .521
Change in $R^2$ .169 .258 .069 .053
$F$ for change in $R^2$ 2.241* 5.500*** 2.638* 2.590*
$F$ for model 2.241* 4.139*** 4.079*** 3.814****

**Note:** OLS = ordinary least squares.

*p < .05

**p < .01

***p < .001 (two-tailed tests)
mance differs depending on whether firms have high or low openness to new ideas. Because the interaction term (University Partnering × Openness to New Ideas) in Model 3 is significant, we know that there is a significant difference in the relationship between university partnering and R&D performance for firms that have low or high openness to new ideas. Results indicate that for firms that are only slightly open to new ideas, R&D performance increases only slightly when firms start to use more university partnering. In contrast, when firms are very open to new ideas, doing more partnering with universities increases R&D performance. Presumably, this relationship occurs because if the focal firm is not open to new ideas, it will not be able to benefit from the ideas obtained via the university partnering relationship because of internal resistance to the new ideas. Thus, we find support for Hypothesis 5—the
more open to new knowledge a firm is, the more positive will be the relationship between university partnering and R&D performance.

The interaction between codifiability and contracting (Hypothesis 11) also has a significant interaction effect, as can be seen in Model 4. To help us interpret the interaction results, we graph the interaction in Figure 3. In all cases, contracting results in decreased R&D performance as hypothesized in Hypothesis 4. However, when the focal firm’s knowledge is less codifiable (more tacit), R&D performance will be less impaired by contracting, presumably because the contractee can less easily make use of knowledge it may obtain via leakage from the focal firm without help from the focal firm. It is important to keep in mind that it is the net gain of R&D knowledge minus loss of knowledge because of leakage to the contractee that is important for determining R&D performance. The other four proposed interaction effects (Hypotheses 6, 7, 9, and 10) were not supported.
Discussion and Conclusions

The purpose of this study was to examine the link between knowledge assets and superior R&D performance with regard to the external sourcing of knowledge by R&D organizations. Several important empirical findings emerge from the analysis.

First, the two different approaches firms use to access external knowledge in their R&D organizations have rather different performance implications. According to our results, the use of external contracting has a net negative impact on R&D performance, whereas the use of partnering with universities has a positive impact on performance. Thus, consistent with social capital theory’s predictions, it appears to be preferable—all else being equal—to use partnering. Specifically, as a function of the structure of social interaction, relationship quality, and partner network ties, partnering results in more knowledge being transferred to the focal firm than when R&D is conducted via contracting. Furthermore, this knowledge can form the basis of superior R&D performance. Compared to contracting, partnering with universities normally results in more interaction between the firm and the university because of the nature of the relationships, which in turn enhances the potential for increased learning. The findings also are consistent with the theoretical logic developed regarding knowledge flows. Where the primary knowledge flow is outward (in the case of contracting), there is likely to be a loss of distinctiveness in the firm’s knowledge assets, and the ability to come up with unique technological breakthroughs will be compromised. Where the primary knowledge flow is inward (in the case of university partnering), the existing knowledge assets of the firm will be enhanced, and new combinations are more likely to emerge. This increases the likelihood of new technological breakthroughs and superior R&D performance.

It is also worth mentioning that an advantage of partnering with universities, as opposed to contracting or partnering via alliances with firms, is that in the latter two modes, the focal firm is partnering with a firm that is a potential competitor as opposed to the case of partnering with universities that are not direct competitors. Partnering with universities, as opposed to potential competitors, has two potential benefits: (a) Universities tend to be more open, as the social norms in academia favor knowledge sharing rather than hoarding, and (b) any outflow of knowledge from the focal firm to the partnering organization is less sensitive in the case of partnering with universities, as universities are not potential competitors.

Second, the overall knowledge context of the firm has an important bearing on R&D performance. Openness to new ideas emerged as the single most important predictor of R&D performance, with a direct effect on performance and also a positive moderating influence on the relationship between partnering and performance. This suggests that openness to new ideas can be viewed as a form of absorptive capacity, in that it represents a cognitive capability to assimilate and act on new ideas. The parallels with the traditional approach to absorptive capacity are worth highlighting. Cohen and Levinthal (1990) recognized the importance of developing technological capabilities inside the firm, so that scientists would have the necessary skills to recognize and make use of new technologies as they arose. Our findings around openness to new ideas suggest a parallel set of cognitive capabilities that are also required for new insights (e.g., from university partners) to be recognized and made use of.

The other aspect of the firm’s knowledge context is its so-called appropriation regime (Teece & Pisano, 1994). Consistent with our predictions, we found that the more codifiable
and the more easily protected a firm’s knowledge assets, the greater its R&D performance. Moreover, we also saw a clear interaction between codifiability and contracting, so that the negative effect of contracting on R&D performance was substantially mitigated in cases where knowledge assets were relatively tacit. In terms of the implications of these findings, the interesting question is the extent to which the appropriation regime of the firm is actively manageable. One way to address codifiability and protection as intrinsic qualities of the firm’s knowledge assets is to see codification as the strategic variable over which managers have a high level of discretion. There are sometimes good reasons not to patent a technology or not to leave knowledge in a tacit form, but this research suggests that firms should actively try to protect their knowledge assets through whatever mechanisms are available. This applies particularly in the case of contracting relationships. In the case of partnering relationships, the situation is more complex because managers have to balance protection of certain knowledge assets with the sharing of other assets.

In terms of theory, this study offers several new insights. First, the empirical results are consistent with social capital theory’s predictions that contracting would be less preferable than partnering. The study also makes several other contributions to theory in terms of providing new insights into the flow of knowledge across firm boundaries. Consistent with the extant literature, we argue that the firm boundary may be viewed as a semipermeable membrane through which knowledge flows to different degrees and at different rates. However, rather than just considering the nature of knowledge (e.g., its codifiability) as determining its ability to flow across firm boundaries, we focused on the specific strategies used by firms to open up their boundaries to both inflows and outflows of knowledge. The permeability of the firm boundary to knowledge flows, in other words, is a function of both the explicit strategies of the firm toward accessing external knowledge and the underlying nature of knowledge.

This insight, in turn, has implications for the RBV of the firm. Knowledge assets, it is argued, can potentially be a source of superior performance if they meet the criteria of rarity, value, inimitability, and nonsubstitutability (Barney, 1991). This study highlights the dynamic nature of such knowledge assets—the ways in which they are enhanced and modified over time and opened up to, or protected from, competitive imitation. It suggests that sustainable superior performance comes not only from the development of higher order capabilities (Dierickx & Cool, 1989) but also from the approach used to either defend or open up the boundaries of the firm.

Finally, the study offers some important implications for management practice. The evidence suggests that, all else equal, to maximize R&D effectiveness, firms should promote university partnering, they should seek to make their knowledge as tacit and defensible as possible (e.g., use patents), they should increase their general openness to new ideas, and they should limit their use of contracting. Because alliance partners (firms) and contractees (firms) are potential competitors, in many ways, it makes sense that universities, which are not potential direct competitors, are preferable R&D partners. After all, universities have good R&D knowledge, and the downside of inevitable knowledge leakage to universities is mitigated by the fact that they are not really potential direct competitors. Furthermore, perhaps because uni-
versities are often conducting different types of research than firms are, universities have good
ability to contribute.

It is worth pondering the question of why firms continue to invest in external contracting
when the evidence from this study and Kessler et al. (2000) suggests that it is detrimental to
performance. The question is similar to the eternal paradox in the merger and acquisition liter-
ature as to why firms undertake so many acquisitions when their net impact on the acquirer is
negative or neutral. We cannot answer this question in a definitive way, but part of the answer
is that the decision to use external contracting has many positive and negative aspects, and the
way these work themselves out in practice is not readily apparent to managers. Moreover, just
as with making acquisitions, there may be competitive or circumstantial factors that simply
require the firm to use external contractors, even if the net impact appears to be slightly negative.

It is possible to speculate that the direction of causality in the relationship between con-
tracting and R&D performance runs the other way—so that high-performing R&D organiza-
tions choose to use less external contracting, whereas those that are struggling outsource
more. This argument certainly has some validity but is not completely convincing because
there are many firms that remain highly innovative despite their high reliance on external con-
tracting relationships (Sawhney & Prandelli, 2000). As is so often the case, the likelihood is
that there is reciprocal causality in this relationship, but with the cross-sectional data collected
in this study, it is not possible to establish causality in a definitive way.

Finally, it should be pointed out that there are also a number of ways to manage around the
potentially negative effects of contracting and knowledge outflows. Some firms, for example,
are very good at building higher order capabilities in speed to market, in customer service, or
in branding (Winter, 1987). If knowledge is viewed solely as an asset, then it is possible for the
firm to put in place systems to protect that asset and enhance its ability to appropriate value
from it. But it is also possible to view knowledge as a capability, in which case the underlying
knowledge assets are simply the tradable inputs on top of which the really valuable (and hard-
to-copy) capabilities are built. In industries where the appropriability regimes are weak, this
knowledge-as-capability approach may be the more valid way of thinking, simply because
firms do not have the option of deriving economic rents from their knowledge assets.

Like all studies, this study has a number of limitations that should be acknowledged. As
always with questionnaire research, there are some concerns as to the value of perceptual mea-
sures, and there are some questions concerning the validity of single-source responses. With
regard to the measurement of R&D performance, this issue is particularly acute, both because
it is the dependent variable in our study and because it is so hard to come up with valid objective
measures. In this research, we opted to focus on subjective measures of R&D performance
(cf. Stones, 2002). Future work should strive to move further in collecting objective R&D
performance-specific data. The second limitation is that the questionnaire data prevented us
from analyzing the mechanisms by which decisions were made or understanding the specific
factors that led to the outcomes we saw. For example, the effect of external contracting on R&D
performance was negative, but this result is likely made up of a variety of positive and nega-
tive factors. It would be interesting to investigate these underlying processes and factors
through a more fine-grained methodology, and this is one issue that future research in this area
should address. Like many studies, we would also have liked to have an even larger data set,
but time-intensive primary data collection prevented this. Indeed, some of the nonsignificant
relationships might have become significant with a larger data set. Thus, it would also be interesting to replicate this study in several additional countries both to increase sample size and to investigate generalizability.

References


Biographical Notes

Carl Fey is an associate professor at the Institute of International Business at the Stockholm School of Economics in Sweden. He has also been helping the Stockholm School of Economics to develop a branch campus for executive development work and research in St. Petersburg, Russia for the past 6 years where he serves as Associate Dean of Research. His work focuses on international aspects of knowledge transfer, innovation, leadership, organizational culture, and strategic human resource management. He has published more than 25 articles in various journals including the *Journal of International Business Studies* and *Organization Science*.

Julian Birkinshaw is Full Professor and Chair of the Department of Strategic and International Management at the London Business School. He is a Fellow of the Advanced Institute of Management Research (United Kingdom) and the Woodside Institute (United States). His main area of expertise is in the strategy and management of large multinational corporations, and on such specific issues as corporate entrepreneurship, innovation, subsidiary-headquarters relationship, knowledge management, network organizations, and global customer management. He is the author of eight books, including *Inventing: Why Big Companies Must Think Small* (2003) and *Entrepreneurship in the Global Firm* (2001), and more than 50 articles.