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R&D Outsourcing and the Effectiveness of Intangible Investments: Is Proprietary Core Knowledge Walking out of the Door?

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ABSTRACT Intangible relationship-specific investments can be double-edged swords, as they facilitate not only the governance of business relationships but also undesired knowledge transfers. Building on transaction costs theory and the relational view of alliances, we analyse the effectiveness of these investments in R&D outsourcing agreements from the viewpoint of the client. We argue that, when outsourcing to business firms, the safeguards adopted by the clients to prevent spillovers may reduce the effectiveness of the supplier's specialized investments. Using original survey data from 170 European and US technology-intensive firms, we find that the contribution of these investments to client performance decreases the more a client's core knowledge is required to perform the service, except when outsourcing to non-profits. This suggests that as the appropriability hazards associated with outsourcing to business firms rise, the client is able to capture less value from the supplier's relationship-specific investments.

Keywords: absorptive capacity, appropriability hazards, intangible relationship-specific investments, proprietary core knowledge, R&D outsourcing

INTRODUCTION

The literature on buyer–seller agreements shows that partners accumulate ever-more valuable resources through relationship-specific investments (RSIs) the longer their relationship endures (Dyer and Hatch, 2006; Madhok and Tallman, 1998; Zajac and Olsen, 1993). Such investments include not only specialized equipment and expertise (Williamson, 1985), but also trust, personal relationships, social commitments, and specific inter-firm coordination mechanisms (Dyer and Singh, 1998; Levinthal and Fichman, 1988; Ring and Van de Ven, 1994). Previous research shows that these investments play a critical role in the performance of buyer–seller agreements (Dyer,

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1996; Kim and Mahoney, 2006; Lado et al., 2008) and, generally speaking, in all kinds of strategic alliances (Ariño and De la Torre, 1998; García-Canal et al., 2003; Zollo et al., 2002). By their nature, RSIs have been found to increase productivity levels (Mesquita and Brush, 2008) and cooperative behaviour (Parkhe, 1993). In addition, they have been found to prompt partners to turn alliances into relational contracts (Macneil, 1980) or self-enforcing agreements (Dyer and Singh, 1998). Therefore, RSIs help partners achieve performance levels that cannot be attained by interacting with other partners.

However, RSIs do not always eliminate non-cooperative behaviour from buyer–seller relationships (Mudambi and Helper, 1998). What is especially intriguing is that, although it is often argued that to foster cooperation, these RSIs should be of a bilateral nature, to avoid opportunistic behaviour by the party not investing (Klein et al., 1978; Williamson, 1985), suppliers are sometimes willing to make unilateral commitments by incurring RSIs without economic safeguards – without a reciprocal sunk cost commitment. This is so because of the spillovers that may arise as a result of these investments in the form of knowledge strengthening their competitive advantage (Kang et al., 2009; Li et al., 2010). Thus, RSIs made by suppliers may in fact entail high appropriability hazards for the client (Kale et al., 2000; Lado et al., 2008). By appropriability hazards, we mean the risk of inadequate uses or modifications of the technology and knowledge transferred, not intended in the contract, and injurious to the transferor. Specifically, the transferor can be worse off under two circumstances. First, when the supplier becomes a future competitor; and second, when the knowledge gained by the supplier benefits other competitors that are actually clients of the same supplier (Kogut, 1988; Oxley, 1997).

Appropriability hazards are especially important in R&D outsourcing agreements, a practice of increasing frequency (Contractor et al., 2010; Doh, 2005; Jensen and Pedersen, 2011; Martínez-Noya et al., 2012). Therefore, in this paper, we analyse the contribution that RSIs made by the R&D supplier make to the performance of the relationship from the client's perspective. We understand performance as the degree of goal fulfilment and overall satisfaction with the supplier (Doz, 1996; Ring and Van de Ven, 1994). The interest of focusing on R&D outsourcing lies in the fact that, when outsourcing these services, clients face a critical dilemma: they have to maintain the necessary knowledge exchange to achieve the alliance objectives, while avoiding the unintended leakage of valuable technology (Grimpe and Kaiser, 2010; Mudambi and Tallman, 2010; Oxley and Sampson, 2004).

We do not expect all RSIs to generate the same appropriability hazards, as a distinction has to be made between tangible and intangible RSIs. Whereas tangible RSIs – such as those involving equipment, machinery, and plants – increase hold-up hazards, intangible RSIs – those based on information flows – increase appropriability hazards. Therefore, intangible RSIs can constitute a double-edged sword because they may facilitate not only a client's goal fulfilment and the development of the relationship, but also undesired knowledge transfers. Building on transaction costs theory and the relational view of alliances, we argue that the impact of intangible RSIs on alliance performance will depend on: (i) the client's need to transfer proprietary core knowledge to the supplier; and (ii) the client's perception of the supplier's opportunities for exploiting the acquired knowledge outside the scope of the agreement. We expect this perception

to depend on the type of organization to which the R&D service is outsourced – that is, a non-profit research centre or a business firm. These organizations may differ on both their incentives and capabilities to exploit the acquired knowledge outside the relationship. We argue that the effectiveness of suppliers' intangible RSIs for the client will decrease the higher the client's need to transfer core knowledge, except when the supplier is a non-profit. We find support for our hypotheses using original survey data from R&D service outsourcing agreements undertaken by technology-intensive firms from the USA and the European Union (EU). Overall, our study highlights how, because of the risk of technological leakage associated with intangible RSIs, client firms may deviate their behaviour, being less cooperative, and lowering the contribution that these investments can have on the focal transaction.

TANGIBLE AND INTANGIBLE RELATIONSHIP-SPECIFIC INVESTMENTS IN OUTSOURCING AGREEMENTS

RSIs can be defined as the 'expenditures dedicated toward the relationship – not just monies but also managerial time, energy, and effort – . . . [that] are specialized to the particular application and not transferable to alternate uses' (Madhok and Tallman, 1998, p. 331). Therefore, RSIs include 'not only the economic and technological resources of participating firms but also social commitments and entanglements of individual agents' (Ring and Van de Ven, 1994, p. 106), and they may be aimed at improving both exchange production and negotiation efficiencies (Mesquita and Brush, 2008). Transaction cost economics has traditionally analysed specific investments as an attribute of the transaction leading to increases in transaction costs. Firms making such investments – usually suppliers – are exposed to the risk of opportunism on at least two fronts. First, specific investments generate hold-up hazards. As these assets are of less value if dedicated to alternative uses, transaction partners face incentives to appropriate the rents from these investments through ex-post contractual bargaining or threats of termination (Klein et al., 1978; Williamson, 1985). Although these opportunistic hazards may always exist, they are conditioned by the balance of the short-term versus long-term gains stemming from non-cooperative and cooperative behaviour, respectively (Mudambi and Helper, 1998). A second type of opportunistic behaviour emerges when a firm reveals valuable knowledge and information to a partner, or just facilitates access to it. The risk that the other party – usually the buyer – may make inadequate use of the knowledge transferred, and which is injurious to the transferor, is usually called an appropriability hazard (Kogut, 1988; Oxley, 1997).

Nevertheless, from a relational view of alliances (Dyer and Singh, 1998; Madhok and Tallman, 1998; Mesquita et al., 2008), these relationally oriented investments, characterized by human specificity and information flows, may make the long-term gains from cooperation outweigh short-term gains from misappropriation of the client's knowledge. Such investments are expected to help partners to develop a better understanding of each other's cultures and management systems, thus enhancing coordination and conflict resolution. It is indeed thanks to these investments that firms can both minimize transaction costs and maximize transaction value (Dyer, 1997), overcoming traditional trade-offs – such as cost versus quality or cost versus flexibility. In fact, Mesquita and Brush

(2008) found that relational contracts may improve both safeguard and task coordination efficiencies in contexts respectively characterized by hold-up and complexity. Hence, although the supplier may take advantage of the knowledge gained from the client, other relational assets would lose their value and the firm would, consequently, see its ability to profit from the relationship curtailed.

Based on this, we argue that a distinction can be made between those RSIs of a tangible nature – physical specialized investments in tooling or equipment – and those more intangible or 'soft' relationally oriented investments – that is, investments in processes, procedures, and people that are specific to the requirements of the client (Zaheer and Venkatraman, 1995). One important implication of this distinction is that the client's attitude towards each type of RSI should be different. Tangible RSIs do not pose any threat to the client beyond the safeguards to be included in the transaction to make such investments possible. Intangible RSIs, however, constitute a 'platform for knowledge transfer' that poses both threats and opportunities for the client. If the supplier were only to exploit the knowledge transferred by the client in future transactions with it, the net effect of intangible RSIs for the client should always be positive. However, as suppliers can capitalize on this knowledge in transactions with other companies (Kang et al., 2009; Li et al., 2010) or in becoming competitors of their clients (Arruñada and Vázquez, 2006), we argue that intangible RSIs made by the supplier can impose important threats for the client from which it will try to be safeguarded, lowering the contribution of these specialized investments to alliance performance.

HYPOTHESES

Intangible RSIs by the supplier can boost performance of the outsourced task as they act as a signal not only of the supplier's willingness to perform its obligations to clients more effectively (Gulati et al., 1994), but also of its aim to develop a long-lasting relationship with its clients, extending the scope of the cooperation (Kang et al., 2009; Li et al., 2010). Although these benefits arise in all outsourcing agreements, in the specific case of R&D, the benefits associated with intangible RSIs are especially important. According to Mowery and Rosenberg (1989) and von Hippel (1994), the main obstacles for outsourcing R&D projects arise when transferring information to the supplier, and when coordinating with it. Thus intangible RSIs, especially if they are of a bilateral nature, are expected to lead to a more effective transfer of the required technological knowledge between them; and the development of organizational routines may facilitate iterative problem solving in technology development (Macher, 2006; McEvily and Marcus, 2005).

Recent research has found, however, that the increased level of sophistication of outsourced activities offers greater learning opportunities for suppliers (Li et al., 2010). Thus, positive effects of intangible RSIs may come at the cost of higher appropriability hazards (Kale et al., 2000; Lado et al., 2008), which may lead the client to adopt safeguards by deciding to limit its investment in mutual intangible RSIs in order to block undesired knowledge leakages. Appropriability hazards will depend on the supplier's relative absorptive capacity against its client (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998). Relative absorptive capability increases when the client transfers firm-specific knowledge to the supplier, when both firms have similar compensation practices

and organizational structures, and when the supplier is familiarized with the client firm's set of organizational problems (Lane and Lubatkin, 1998). Thus, when analysing the potential appropriability hazards in an outsourcing agreement, the identity of the supplier also matters. Specifically, Foss et al. (2011) showed that organizational practices have an impact on individual incentives to absorb and transfer external knowledge. For this reason, these hazards would be dependent on the profit orientation of the supplier.

We argue that the client's assessment of the potential appropriability hazards as a result of the R&D supplier developing intangible RSIs, will depend on: (i) the client's need to transfer proprietary knowledge core to its value proposition; and (ii) the inadequate use that the supplier may make of the acquired knowledge, which would be dependent on its profit orientation. We develop these propositions in the following section.

Amount of Client's Proprietary Core Knowledge Required to Perform the R&D Service

Intangible RSIs act as 'platforms' for knowledge transfer – specially, if these investments are mutual[1] – because they increase the familiarity of the supplier with the client's knowledge base, and thus the supplier's relative absorptive capacity against its client (Lane and Lubatkin, 1998). This higher relative absorptive capacity against its client will allow the supplier to perform the assigned activities more effectively owing to coordination and communication improvements. However, we argue that this latter effect can generate important appropriability hazards for the client depending on the amount of proprietary core knowledge required to be transferred to the supplier, as it may lead to a dilution of its strategic resources (Grimpe and Kaiser, 2010). This is so because, although the knowledge required to perform the service may be partly codified, owing to the inseparability of knowledge and the embeddedness of specific knowledge within the firm routines, it may be very difficult for the client to clearly isolate both the kind, and the extent, of specific knowledge being transferred to its supplier. Moreover, the higher the transfer of this kind of knowledge, the more likely the client will need to assist the supplier in improving its understanding of the tacit knowledge, which may ultimately increase appropriability hazards (Mudambi and Tallman, 2010). Thus, when outsourcing R&D services requiring large transfers of proprietary core knowledge, suppliers can tap into the platform for knowledge transfer built through these intangible RSIs to absorb client-specific information in such a way that the supplier would be fully prepared to exploit this knowledge. This could explain why some OEM suppliers are willing to make unilateral investments in equipment, operating procedures, and systems that are specialized to a particular client. As argued by Kang et al. (2009), inexperienced OEM suppliers view these relationships as a strategic move owing to the positive spillovers they may yield from future transactions, not only with the same client but also from other parties.

Although, initially, it could be thought that firms would never outsource those services requiring the transfer of proprietary core knowledge, there could be situations in which they may nevertheless be forced to do so owing to limited skills, the need to speed up the innovation process, or because a specialized supplier may perform the service at a lower cost (Martínez-Noya and García-Canal, 2011). In fact, the growth of knowledge process

outsourcing (Mudambi and Tallman, 2010; Mudambi and Venzin, 2010) is unquestionable evidence of its existence. Within this context, intangible RSIs may act as a facilitator for undesired knowledge transfers that may imply a potentially risky upgrading of the supplier's technological competence (Arruñada and Vázquez, 2006; Larsson et al., 1998). While these investments may indeed contribute to performance within the R&D outsourcing agreement, we argue that client firms will be able to capture less value from the supplier's RSIs because far-sighted firms will adopt safeguards to avoid misuse of their proprietary knowledge. Therefore, although in a world without appropriability hazards, maximum transaction value would be generated if mutual intangible RSIs exist, these safeguards might entail a choice by the client to under-invest in intangible RSIs to avoid misappropriation issues, even at the cost of a lower performance of the outsourced task. By limiting their intangible RSIs, client firms would be trying to avoid the situation that Hamel (1991) calls learning races, in which each firm tries to speed up its learning rate to reach their individual goals first before defecting on the other. Although partners can develop complex contracts to protect their knowledge when self-enforcing safeguards are not effective (Reuer and Ariño, 2007), the client's notion of the supplier's ability to exploit the information exchanged beyond the scope of the agreement might deviate its behaviour from the theoretically optimal one aimed at maximizing the value of the focal transaction (Khanna et al., 1998).

Outsourcing services that do not require the client to transfer core knowledge to the supplier are different because appropriability hazards are substantially reduced. Within this low-risk context, based on the relational view of the firm, we expect these investments to boost performance, helping firms to both minimize transaction costs and maximize transaction value (Dyer, 1997). Thus:

> *Hypothesis 1*: The contribution to client performance of intangible relationship-specific investments made by the R&D service supplier will decrease as the amount of core knowledge that is required to perform the service increases.

The Case of Outsourcing R&D Services Requiring Proprietary Core Knowledge to Non-Profit Research Centres

When analysing the extent of appropriability hazards faced by the client as a result of the supplier developing intangible RSIs, one important factor to consider is the identity of the supplier. R&D outsourcing agreements signed with non-profit organizations, such as universities or research institutes, deserve special attention (Lam, 2007). Compared to business firms, non-profits have different motivational or strategic orientation (Das and Kumar, 2011; Li et al., 2010). Thus, they are expected to have lower incentives to apply the knowledge gained via the outsourcing relationship to markets or products outside of the agreed-upon scope, which lowers appropriability hazards (Bresser, 1988; Caves et al., 1983). Indeed, Bercovitz and Feldman (2007) found that universities are preferred to other external partners when the firm perceives potential conflicts over intellectual property, as in fact, the main incentive of scientists in non-profit research centres is to publish; a risk easy to control by the client that can be addressed contractually.[2] In addition, non-profit research centres face more difficulties than business firms to obtain

the complementary assets necessary to exploit the client's knowledge (Teece, 1986). Consequently, the downside of knowledge leakages as a result of intangible RSIs when outsourcing services requiring core knowledge will be mitigated.

In the presence of low incentives for opportunistic behaviour, we expect potential spillover effects due to intangible RSIs by the supplier not to be negatively perceived by the client, and thus, mutual intangible RSIs are expected, fostering transaction value. Previous studies have shown that a firm's decision to choose a technological partner is largely determined by the contribution it can make in terms of knowledge and innovation (Santamaria and Rialp, 2007). Indeed, research has found that higher incoming spillovers positively affect the probability of cooperating with research institutes (Cassiman and Veugelers, 2002), and that universities and research institutes constitute a very important source of knowledge for R&D-intensive firms (Belderbos et al., 2004; Bercovitz and Feldman, 2007) that is also useful to entrepreneurial activity (Shane, 2004). Furthermore, Fey and Birkinshaw (2005) showed that accessing external knowledge from universities leads to higher R&D performance because the nature of these relationships enhances the potential for increased learning on the side of the focal firm. Therefore, we argue that, when outsourcing to non-profits, the transfer of proprietary core knowledge is not expected to generate important hazards for the client. Consequently, intangible RSIs on the side of the supplier can boost the effectiveness of R&D outsourcing agreements, as the long-term gains stemming from cooperation clearly outweigh the short-term benefits that may result from non-cooperative behaviour. Thus:

Hypothesis 2: When the R&D supplier is a non-profit research centre, the contribution to client performance of intangible relationship-specific investments made by the supplier will increase as the amount of core knowledge that is required to perform the outsourced service increases.

DATA AND METHODS

Research Setting and Data

We conducted a mail survey on a sample of US and EU firms with more than 100 employees competing in R&D-intensive industries whose two-digit SIC code is included in the OECD classification of technology-intensive industries (OECD, 1997): chemicals and allied products (28); transportation equipment (35); computers and electronics (36); industrial machinery (37); and analysis and measurement equipment (38). We stratified the sample according to industry and firm size to ensure external validity using the *Dun and Bradstreet Million Dollar Database* (see Table AI in the Appendix).

To overcome the problems associated with the key informant approach, we developed the survey in several stages. First, to develop a comprehensive questionnaire, we conducted interviews with the heads of technology and innovation of a large US-based multinational firm. Second, we reviewed the literature to identify relevant scale items for the concepts we wanted to measure. Finally, to avoid misunderstandings due to the international nature of the targeted population, the questionnaire was pre-tested on seven R&D managers located in different countries, and written in five languages:

English, French, German, Italian, and Spanish. These translations were made by native speakers in the different languages, who were bilingual in English and academic experts in management. Besides, all the versions were available on the internet, so the respondents could easily choose the language preferred to complete the questionnaire. The questionnaire was mailed to the firm's chief executive officer along with a request to pass it on to the head of R&D or technology if desired. The returned questionnaires were filled out by senior managers: CEOs, VPs, and heads of R&D, technology, or engineering departments. After following the principles of the Total Design Method (Dillman, 1978), we obtained a final sample of 182 usable responses (81 for the USA and 101 for the EU) representative of the spectrum of firms in terms of industry, country of origin, and firm size (see Table AI). After excluding the undeliverable addresses, our response rates were 4.5 per cent for the USA and 5.3 per cent for the EU. When comparing early and late respondents, we found no significant differences in terms of all the variables used in the study. This suggests that a significant non-respondent bias is unlikely.

We asked firms to indicate which R&D service activities they were outsourcing from a comprehensive list, and where. After an exhaustive literature review of different sources on innovation, and business and statistical reports on R&D, we identified a list of R&D services or stages that could potentially be outsourced by technology-intensive firms in the selected industries. This list was refined with the help of a consulting firm and several R&D managers. Of the firms, 108 of 182 were outsourcing at least one of these services, and 96 of them more than one. We asked these firms to identify the most representative and regularly outsourced service (in terms of the resources compromised and volume contracted), and asked different questions related to the attributes and performance of this outsourcing relationship. Table AII presents descriptive statistics on the type of services being outsourced by type of supplier. Missing data on some of the variables reduced the sample to 170 usable questionnaires, with 99 of the firms reporting that they outsourced one or more R&D services. To avoid common-method bias, we used techniques related to questionnaire design suggested by Podsakoff et al. (2003), and Harman's single-factor test (Harman, 1967) suggested the absence of common-method bias. Moreover, our results are based on estimations that involve multiple independent variables and interaction terms. Evans (1985) has shown that interaction effects are robust against common-method bias.

Method of Analysis

As the R&D outsourcing decision represents a choice variable not randomly distributed across the sample, our analysis is susceptible to self-selection bias. To assess and correct for this we used the standard two-stage technique (Heckman, 1979), which consists of re-estimating the regression coefficients by introducing an adjustment term into the second-stage model (i.e. the inverse Mills ratio). This approach enabled us to obtain consistent and unbiased estimates in the second-stage regression model (Shaver, 1998). We implemented this Heckman two-stage regression model in STATA, using the HECKMAN procedure in which the first stage is a probit model and the second stage is an OLS regression. While in the first-stage model, the unit of analysis is the firm, in the

second-stage model, the unit of analysis is the most representative R&D outsourcing agreement for each firm.

Measures

Stage 1: Outsourcing decision selection. The dependent variable (OUTSOURCING) is valued 1 when the client outsources any R&D service to suppliers located either in the home country or abroad, and 0 otherwise. We included the following independent variables based on previous research: the number of patents assigned to the firm until the end of 2006, as recorded by the United States Patent and Trademark Office (USPTO). To control for industry biases we divided the number of patents assigned to each firm by the number of patents assigned to the firm with the most patents in the same sector. Thus, PATENTS ranges from 0 to 1. The index of protection of intellectual property rights (IPR) was developed by Ginarte and Park (1997), and was updated by Park for the year 2000.[3] It assigns a value from 0 to 5 to each country depending on the strength of its national patent legal system. We included four dummy variables depending on the response of the interviewee to a question asking which of the following statements best applied to the company: (1) R&D activities represent the basis of our company's competitive strategy, so research guides the actions of the remaining areas or departments (R&D STRATEGY–BASIS); (2) the R&D department must support our company's competitive strategy, so it must coordinate and align its objectives and actions with the other departments (R&D STRATEGY–ALIGNED); (3) the R&D department must be effective and competitive, but it operates very independently compared with other departments (R&D STRATEGY–INDEPENDENT); and (4) our company considers that the R&D department has no influence on the company's competitiveness and just buys the technologies available on the market (R&D STRATEGY–NO INFLUENCE). Category (2) was used as the reference for the rest of the variables. Finally, we introduced the FIRM SIZE variable (the logarithm of the firm's sales during 2005 in US dollars) and industry controls.

Stage 2: Level of performance achieved in the outsourcing relationship. We define performance from the perspective of the client, that is, as how well the relationship has fulfilled a client's strategic needs (Parkhe, 1993) in terms of goal fulfilment and degree of development of the relationship. To code this variable, we used perceptual measures of performance. Research shows that subjective measures of performance are well correlated with objective measures (Dess and Robinson, 1984), especially when the respondents are top managers (Krishnan et al., 2006). We followed Ariño's (2003) definition of alliance performance. Consistent with the relational view (Dyer and Singh, 1998), Ariño argues that both the outcome performance dimension (i.e. the degree of accomplishment of the partners' goals, be these common or private, initial or emergent) and the process performance dimension (i.e. the extent to which their pattern of interactions is acceptable to the partners) need to be captured. Specifically, our measure is integrated by nine survey items. Using a Likert scale from 1 (low) to 5 (high), respondents indicated the degree to which (a) the firm achieved the following seven strategic goals in the outsourcing relationship with the main supplier of the R&D service being analysed (OUTCOME DIMENSION): (1) increased flexibility; (2) cut production costs; (3) cut administrative

and management costs; (4) faster access to markets; (5) increased service quality levels; (6) increased firm performance due to a greater concentration of resources on the development of its core activities; and (7) reduction of time-to-market; and (b) they agreed with the following statements in relation to its R&D service supplier (PROCESS DIMENSION): (8) the supplier is a reliable firm; and (9) the supplier has a long-lasting relationship with our firm. These nine measures were averaged for each firm to create a composite performance index (PERFORMANCE) capturing both dimensions (Cronbach's alpha = 0.75).

Our independent variables were constructed as follows. To capture the client's need to transfer proprietary core knowledge to the supplier, we introduced CORE KNOWLEDGE. To develop this variable, we used a Likert (1–5) scale and asked the interviewees to indicate their level of agreement with the following statements related to the attributes of the R&D service outsourced: (1) individuals must acquire company-specific or division-specific information to perform the service adequately; (2) it is difficult for third parties to understand the company know-how related to this service. Thus, these items capture the dimensions of firm-specificity and tacitness of the knowledge being transferred (Cronbach's alpha = 0.7) and they were adapted from the works of Poppo and Zenger (1998) and Kogut and Zander (1993).

To account for those RSIs in human assets, knowledge-sharing routines, and organization processes aimed at facilitating knowledge transfer and understanding between the parties as well as to develop a trustful relationship, we introduced the variable INTANGIBLE INVESTMENTS. To develop this measure, we used a Likert (1–5) scale and asked the interviewees to indicate their level of agreement with the following statements: (1) 'the supplier incurred high costs in training its staff to meet the specific requirements of our company'; (2) 'the supplier has always shown its commitment to our firm'; (3) 'the supplier has invested in developing knowledge-sharing routines with our company'; (4) 'a high level of personnel transfer exists between the supplier and our company'; and (5) 'the supplier is willing to share its knowledge with our company' (Cronbach's alpha = 0.702). To capture the level of physical investments made by the supplier to adapt its plant and equipment to the specific requirements of the client, we introduced TANGIBLE INVESTMENTS. To develop this variable, we used a Likert (1–5) scale and asked the interviewees to indicate their level of agreement with these statements: (1) 'the supplier made important investments to adapt its plant and facilities to the specific requirements of our company'; (2) 'the supplier increased its capacity to work for our company'; and (3) 'the supplier has set up new facilities or plants near some of our production plants'. These three items measure Williamson's (1985) dimensions of physical specific investments (Cronbach's alpha = 0.742). To account for the type of organization to which the R&D service was outsourced, we introduced NON-PROFIT RESEARCH CENTRE, coded as 1 if the interviewee indicated that the supplier was a university or a research institute, and 0 if it was a business firm.

Because some types of R&D services may be more likely to require the transfer of core knowledge, and thus affect the appropriability hazards perceived by the client, we included dummy variables to control for the services most frequently being outsourced in our sample, namely, BASIC RESEARCH, PRODUCT DESIGN, SOFTWARE, PROCESS DESIGN, and APPLIED RESEARCH (see Table AII). Similarly, because

our argument for suppliers to be willing to make unilateral RSIs is that they can capitalize on the acquired clients' knowledge in transactions with other companies, and single sourcing has been considered to have trust-building properties (Mudambi and Helper, 1998), to assess for the client perception of risk of knowledge leakage to competitors through the supplier, we included the control variable CONTRACTS WITH CLIENT COMPETITORS. This variable captures, on a 1–5 scale, the interviewee's level of agreement with the statement: 'the supplier also has outsourcing relationships with some of our competitors'. To reduce biases stemming from the longevity of the relationship, we introduced RELATIONSHIP TENURE that controls for the year the firm first signed a contract with the supplier. Furthermore, because the strength of the control mechanisms may vary across different types of governance (Madhok, 1996), to better control by type of governance, we included JOINT VENTURE (coded as 1 when the outsourcing agreement involves a joint venture between the parties, and 0 otherwise); and LONG-TERM CONTRACT (coded as 1 if it involves a long-term contract between the parties, and 0 otherwise). To control for the potential of knowledge spillovers between the parties, we introduced MULTIPLE PROJECTS that takes the value 1 if the supplier provides more services to the company, and 0 otherwise (Kang et al., 2009). To account for the contractual costs arising owing to the nature of the activity in connection with the supplier's location (Delios and Henisz, 2000; Hill et al., 1990), we introduced INTERNATIONAL NON-OECD SUPPLIER, coded as 1 if the supplier is located in a non-OECD country, and 0 otherwise, and INTERNATIONAL OECD SUPPLIER, coded as 1 if the service supplier is located abroad but within a country belonging to the OECD. Domestic suppliers act as the reference category. Finally, we also added the following controls from the first-stage model to account for other sources of firm heterogeneity: PATENTS, R&D STRATEGY–BASIS, IPR, FIRM SIZE, and industry dummies.

RESULTS

Table I shows the correlations and descriptive statistics for the main variables used in the second stage.[4] Given the high correlations between the interaction terms and the main effects, we mean-centred the relevant continuous variables before calculating the interactions (Jaccard and Turrisi, 2003).

First-Stage Outsourcing Decision Estimates

Table II reports maximum-likelihood estimates for the outsourcing decision probit model. As the main purpose of this model is to account for endogeneity, we just include the estimates for the sake of brevity.

Second-Stage Performance Estimates

Table III reports the results of our performance regression models controlling for self-selection using five different specifications. An *F*-test of the null hypothesis that all the coefficients are jointly 0 is rejected in all the models. The estimated coefficients for the

Table I. Second-stage descriptive statistics and correlation matrix

Variables	*Mean*	*S.D.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
1. Performance	3.3	0.5																				
2. Tangible investments	1.8	0.8	0.27*																			
3. Intangible investments	2.9	0.8	0.46*	0.44*																		
4. Core knowledge	3.0	1.0	0.41*	0.08	0.49*																	
5. Non-profit research centre	0.1	0.3	−0.28*	−0.03	−0.12	−0.13																
6. International OECD supplier	0	0.4	−0.09	0.04	−0.08	−0.21*	0.02															
7. International non-OECD supplier	0.1	0.3	0.12	0.13	0.22*	0.10	−0.17	−0.22*														
8. JV	0.0	0.2	−0.09	−0.03	0.10	0.13	−0.10	−0.04	−0.02													
9. Long-term contract	0.1	0.3	0.00	0.52*	0.22*	0.04	0.05	0.03	0.14	−0.12												
10. Relationship tenure	1995	10	−0.09	0.03	−0.01	−0.15	0.10	0.03	0.10	−0.04	0.15											
11. Multiple contracts	0.6	0.4	0.08	−0.01	0.08	0.18	0.12	−0.11	0.12	0.02	−0.05	0.09										
12. Contracts with client competitors	3.6	1.4	−0.13	−0.20*	−0.00	0.04	−0.04	−0.08	0.02	0.06	0.02	0.06	0.14									
13. Patents (adjusted)	0.0	0.1	0.10	0.34*	0.16	−0.00	−0.09	0.22*	0.12	0.10	0.20*	−0.09	−0.20*	−0.18								
14. R&D strategy–basis	0.1	0.3	−0.06	−0.02	−0.08	0.07	−0.02	0.12	0.05	−0.06	−0.01	0.14	0.00	0.09	−0.08							
15. IPR	4.6	0.3	0.07	−0.02	0.19	0.16	−0.17*	0.10	0.13	0.03	−0.03	0.19	0.12	−0.09	0.15*	−0.12						
16. Firm size (log)	17.9	1.6	0.07	0.41*	0.35*	0.21*	−0.08	0.01	0.20*	0.23*	0.32*	−0.10	−0.01	−0.14	0.31*	−0.11	0.11					
17. Basic research	0.1	0.3	−0.01	−0.00	−0.04	−0.21*	0.23*	0.12	−0.22*	−0.04	0.10	0.18	0.02	−0.17	0.04	0.04	−0.04	0.02				
18. Applied research	0.0	0.2	−0.09	0.03	0.04	0.11	0.03	−0.01	0.00	0.15	0.00	−0.14	−0.00	0.01	0.14*	0.04	0.02	0.23*	−0.08			
19. Software	0.0	0.2	0.04	0.08	0.00	0.09	−0.13	−0.14	0.33*	0.10	0.02	0.09	0.28*	0.01	0.14	0.05	0.16*	0.07	−0.10	−0.07		
20. Product design	0.0	0.29	0.15	−0.05	0.21*	0.16	−0.14	−0.16	−0.06	−0.12	0.02	0.00	0.02	0.13	−0.06	0.03	−0.05	−0.02	−0.11	−0.08	−0.09	
21. Process design	0.0	0.26	0.07	−0.09	−0.16	−0.06	−0.06	0.15	0.12	−0.11	−0.11	−0.04	−0.05	−0.05	0.07	−0.03	0.12	−0.03	−0.10	−0.07	−0.08	−0.09

Note: * Significant at the 5% level.

Table II. Results of maximum-likelihood probit analysis for outsourcing decision (n = 170)

Independent variables	*Full model*
Patents	1.139 (2.90)***
IPR	0.308 (1.59)
R&D strategy–basis	−0.573 (2.31)**
Patents × R&D strategy–basis	7.401 (2.44)**
R&D strategy–no influence	−0.139 (0.26)
R&D strategy–independent	0.208 (1.03)
Firm size (log)	−0.102 (1.41)
SIC28	0.389 (1.95)*
SIC36	0.324 (1.71)*
SIC37	0.452 (1.51)
SIC38	0.120 (0.43)
Constant	0.186 (0.12)
Log pseudo-likelihood	−112.93

Notes: Robust z statistics in parentheses.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

inverse Mill's ratio (lambda) in all the models are significant, indicating the presence of self-selection. Consequently, the use of Heckman's (1978, 1979) technique is justified.

INTANGIBLE INVESTMENTS is positive and significant across models. However, consistent with Hypothesis 1, predicting a lower contribution of intangible RSIs to performance as the amount of client's core knowledge required to perform the service increases, we find that the interaction term INTANGIBLE INVESTMENTS × CORE KNOWLEDGE is negative and significant (models III and V). Consistent with our Hypothesis 2, predicting that when the R&D supplier is a non-profit, the contribution to performance of intangible RSIs made by the supplier will increase as the amount of client's core knowledge required increases, we find that the interaction term INTANGIBLE INVESTMENTS × CORE KNOWLEDGE × NON-PROFIT RESEARCH CENTRE is positive and significant (model V). We display the effects of these interactions on the performance achieved in the R&D outsourcing agreements with business firms (Figure 1) and with non-profits (Figure 2) for different requirements of client's core knowledge, that is, when CORE KNOWLEDGE takes the minimum, mean, and maximum values.

As shown in Figure 1, when outsourcing to business firms, the more a client's core knowledge is required to perform the service, the lower the contribution to performance of intangible RSIs on the side of the supplier. In particular, we observe that these investments seem to contribute to superior performance when the service outsourced to these suppliers is quite standardized – that is, when the variable CORE KNOWLEDGE takes its minimum value – although this positive effect clearly diminishes when the service requires the client to transfer a high amount of core knowledge. In contrast, as shown in Figure 2, when outsourcing to research centres or universities, the more a client's core knowledge is required to perform the service, the higher the contribution to

Table III. OLS estimates for second stage performance models (n = 91)

Independent variables	*Model I*	*Model II*	*Model III*	*Model IV*	*Model V*
Intangible investments		0.259 (2.83)***	0.321 (3.91)***	0.274 (2.95)***	0.305 (3.68)***
Core knowledge		0.129 (3.06)***	0.103 (2.06)**	0.139 (3.41)***	0.093 (1.82)*
Non-profit research centre		−0.480 (3.03)***	−0.555 (4.08)***	−0.451 (2.83)***	−0.184 (0.88)
Intangible investments × core knowledge			−0.172 (2.51)**		−0.157 (2.31)**
Non-profit research centre × intangible investments					1.327 (2.31)**
Non-profit research centre × core knowledge					0.667 (2.16)**
Non-profit research centre × intangible investments × core knowledge					2.027 (2.24)**
Tangible investments	0.210 (3.87)***	0.048 (0.69)	−0.010 (0.14)	0.062 (0.86)	−0.004 (0.06)
Tangible investments × core knowledge				0.078 (1.37)	
Basic research	0.282 (1.94)*	0.258 (2.11)**	0.324 (2.40)**	0.246 (2.11)**	0.345 (2.57)**
Applied research	0.317 (1.70)*	0.047 (0.26)	0.183 (1.03)	0.043 (0.26)	0.223 (1.26)
Software	−0.025 (0.12)	−0.061 (0.34)	0.028 (0.19)	−0.082 (0.45)	0.087 (0.57)
Product design	0.418 (2.54)**	0.011 (0.07)	−0.012 (0.08)	0.035 (0.21)	0.058 (0.39)
Process design	0.124 (0.86)	0.233 (1.69)*	0.257 (1.83)*	0.244 (1.75)*	0.279 (2.02)**
Contracts with client competitors	−0.071 (1.84)*	−0.071 (2.66)***	−0.060 (1.97)**	−0.066 (2.44)**	−0.064 (2.14)**
Relationship tenure	−0.005 (1.10)	0.002 (0.42)	−0.000 (0.10)	0.002 (0.48)	−0.002 (0.35)
Multiple projects	0.153 (1.12)	0.228 (1.84)*	0.255 (2.42)**	0.222 (1.78)*	0.198 (1.85)*
Joint venture	−0.006 (0.03)	−0.202 (1.22)	−0.085 (0.51)	−0.212 (1.28)	−0.093 (0.58)
Long-term contract	−0.047 (0.33)	−0.056 (0.45)	−0.076 (0.59)	−0.052 (0.43)	−0.043 (0.34)
International OECD supplier	−0.073 (0.52)	0.006 (0.06)	0.025 (0.22)	0.027 (0.25)	0.028 (0.25)
International non-OECD supplier	0.194 (1.67)*	−0.055 (0.44)	−0.054 (0.41)	−0.076 (0.60)	−0.052 (0.42)
Patents	0.001 (1.42)	0.001 (2.68)***	0.001 (2.06)**	0.001 (2.78)***	0.001 (1.75)*
R&D strategy–basis	0.221 (1.60)	0.110 (0.82)	0.076 (0.60)	0.091 (0.73)	0.083 (0.67)
IPR	0.099 (0.69)	−0.186 (1.45)	−0.204 (1.70)*	−0.173 (1.34)	−0.186 (1.64)
Firm size (log)	−0.015 (0.40)	−0.045 (1.27)	−0.052 (1.47)	−0.051 (1.43)	−0.051 (1.55)
SIC28	−0.279 (1.62)	−0.299 (1.87)*	−0.402 (2.73)***	−0.231 (1.31)	−0.374 (2.63)***
SIC36	0.230 (1.56)	−0.076 (0.49)	−0.110 (0.78)	−0.045 (0.29)	−0.081 (0.61)
SIC37	−0.106 (0.43)	−0.085 (0.45)	−0.011 (0.06)	−0.052 (0.28)	−0.014 (0.08)
SIC38	−0.312 (1.63)	−0.412 (2.95)***	−0.483 (3.08)***	−0.331 (2.21)**	−0.365 (2.37)**
Constant	12.107 (1.43)	1.304 (0.15)	6.043 (0.71)	0.622 (0.07)	8.219 (0.95)
Lambda (λ)	0.539***	0.348**	0.348**	0.337**	0.263*
Log-pseudo likelihood	−152.65	−137.48	−134.42	−136.77	−131.72
Wald X^2	99.44***	144.04***	119.35***	153.11***	133.83***

Notes: Robust z statistics in parentheses.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

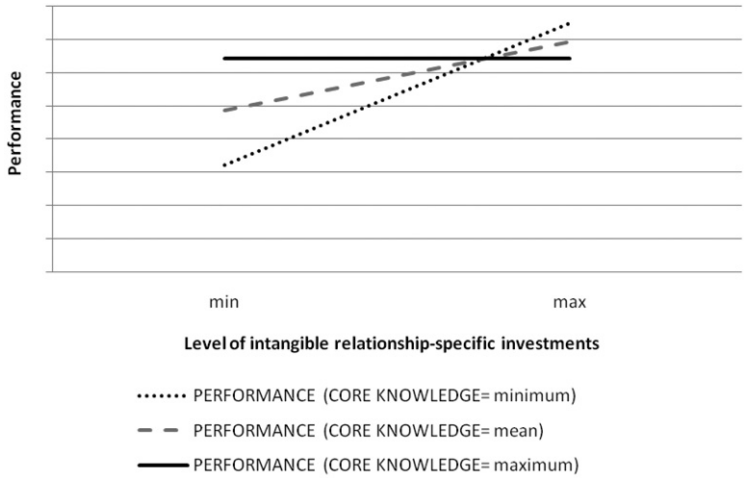

Figure 1. Net impact of intangible relationship-specific investments on the performance of R&D outsourcing agreements with business firms.

Note: Using the estimates from model V in Table III. Control variables were evaluated at the sample mean.

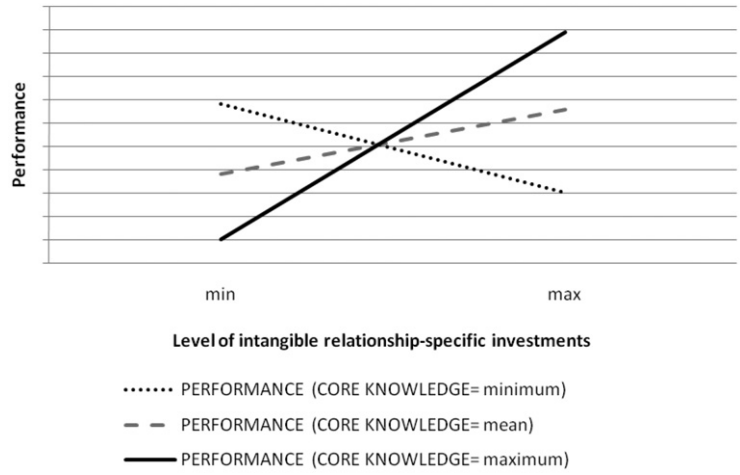

Figure 2. Net impact of intangible relationship-specific investments on the performance of R&D outsourcing agreements with non-profit research centres.

Note: Using the estimates from model V in Table III. Control variables were evaluated at the sample mean.

performance of the intangible RSIs made by the supplier. In fact, these investments seem to be especially effective when outsourcing R&D services requiring the transfer of large amounts of core knowledge to these institutions.

Some of the results involving the control variables deserve attention. The positive and significant sign of BASIC RESEARCH across models suggests that outsourcing basic research services – activities that are closer to science and are thus of lower direct commercial relevance for the external partner (Shane, 2004) – lead to superior perform-

ance. The negative and significant sign of CONTRACTS WITH CLIENT COMPETITORS indicates that performance decays when suppliers work also for clients' competitors. Finally, tangible RSIs do not influence performance.

DISCUSSION

While studies on the impact of RSIs on the performance of outsourcing agreements have focused mainly on hold-up hazards, our paper focuses on appropriability hazards. We argued that the development of intangible RSIs on the side of the supplier may have a positive contribution to a client's performance in R&D outsourcing agreements, in terms of both the client's goal fulfilment and degree of development of the relationship. However, it also increases appropriability hazards in such a way that the client can limit its transparency and cooperative behaviour in order to avoid too much exposure of its core technology. Specifically, we argued that the extent to which these hazards will be perceived by the client firm as a competitive threat will depend on the amount of proprietary core knowledge transferred to the supplier, and on the supplier's profit orientation.

The empirical results confirmed our hypotheses. Although we found that, overall, intangible RSIs on the side of the supplier may contribute to client performance when outsourcing R&D services – consistent with findings of previous studies on non-R&D alliances (Dyer and Singh, 1998; Parkhe, 1993; Zollo et al., 2002) – we also found that this positive effect does not hold across all kinds of R&D outsourcing agreements. The client ability to capture all the value stemming from these investments appears to be dependent on the potential spillovers these investments generate for the supplier, which will ultimately be determined by the client's need to transfer core knowledge to it, and on the opportunity set by the supplier to exploit the acquired knowledge outside the R&D agreement.

These investments appear to be very effective for the client when the supplier is a research centre, because in this case the supplier has a low risk of both becoming a competitor and/or exploiting the knowledge gained via the outsourcing relationship to markets outside of the agreed-upon scope. In contrast, when outsourcing to business firms the positive effect these intangible RSIs may have on alliance performance diminishes as the amount of proprietary core knowledge transferred increases. In these cases, the client's awareness of the higher appropriability hazards involved may lead it to adopt stronger safeguards by limiting their own intangible RSIs, triggering alliance management difficulties that will have the drawback of lowering the performance of the outsourced task. It relation to this, it should be highlighted that although the overall performance achieved by the client may be lower than the one obtained in a scenario without appropriability hazards, this is not a suboptimal behaviour, as performance would be expected to be even lower if these precautions were not taken by the client.[5] It should be noted that the negative interaction between core knowledge and intangible RSIs could just reflect the increased communication/coordination challenges of dealing with complex or tacit knowledge. Non-profit research centres, given their strong technical personnel, may be better equipped to deal with 'cutting-edge' proprietary technology (Bercovitz and Feldman, 2007). Despite this, the first argumentation gets reinforced by two additional findings: (1) the negative impact on performance of CONTRACTS

WITH CLIENT COMPETITORS, a proxy for potential negative spillovers; and (2) the positive and significant effect of BASIC RESEARCH, which are services closer to science and more difficult to have a direct commercial exploitation (Shane, 2004). Indeed, as proof of the importance of clients' expectations about the behaviour of their suppliers, and the expected spillovers to actual or future competitors, we tested the interaction of CONTRACTS WITH CLIENT COMPETITORS with NON-PROFIT RESEARCH CENTRE, but the interaction effect was non-significant. This means that the risk of knowledge spillovers to competitors through the supplier negatively contributes to alliance performance from the perspective of the client, no matter the profit orientation of the supplier. Thus, taken together, our results suggest that client firms may lower their transparency and cooperative behaviour, and thus their ability to capture all the coordination and communication benefits from the supplier's intangible RSIs, not only when the activities require the transfer of core proprietary knowledge that can be misappropriated through these investments, but also when the supplier is supplying direct competitors (even if the supplier is a non-profit research centre).

Our findings give support to the relational view of alliances, providing evidence that, in some cases, making intangible RSIs allows the firm to overcome the traditional costs versus flexibility or cost versus quality trade-offs, making effective use of the information flows between the partners, and maximizing the value of the relationship (Dyer, 1997). That was the reason for including in the dependent variable objectives that could be contradictory in other contexts – such as cost efficiency, flexibility, and quality improvements. However, as a robustness test to discard potential biases in our dependent variable, we re-estimated our models using a revised performance variable with the two cost items ('cut production costs' and 'cut administrative and management costs') removed, and the same results were obtained.[6] We also tested the robustness of our results to alternative specifications of our dependent variable. As previously mentioned, consistent with the relational view, our dependent variable includes both outcome and process dimensions of alliance performance, which, according to previous research, tend to be correlated. Doz (1996) and other research on alliance evolution (Ariño and De la Torre, 1998; Ring and Van de Ven, 1994) show how alliances obtaining more positive outcomes are the result of iterative processes through which firms build trust as they gain in adaptive flexibility, and in the willingness to increase their commitment. Obviously, this correlation between outcome and process dimensions is not perfect, as there may be cases in which, despite accomplishing some outcomes, the relationship is discontinued because of the lack of willingness to invest in the relationship. For these reasons, we tested an alternative way of calculating our performance variable in which we assigned a higher weight to the process dimension (a 50 per cent weight to the outcome items, and 50 per cent to the process items), and the same results were obtained.[7]

Our findings complement results obtained by Mudambi (2008), arguing that benefits from outsourcing seem to be stronger when it focuses on processes that are non-core to the client. Our study confirms that this is in fact the case, unless the service supplier is a non-profit research centre presenting low risk of inadequate use of the acquired knowledge. Our results also confirm those of Sampson (2004), who highlighted the mediating role absorptive capacity has on appropriability hazards. They also complement Kang et al.'s (2009) work, which found that suppliers may make unilateral RSIs without

ex-ante economic safeguards, as these can yield them both positive knowledge and reputation spillovers. We extended these results by finding that, in the case of partnering business firms, these positive knowledge spillovers for the supplier may trigger alliance management difficulties, which may lead the client to capture less value from these investments. Our findings are aligned with those of Li et al. (2010), who argued that when choosing the proper supplier, firms should pay more attention to the cooperation goals or strategic orientation of the suppliers in order to improve collaboration effectiveness and efficiency. Our findings are also aligned with those of Khanna et al. (1998), as we found that the client's notion of the supplier's opportunities to apply what it learns in the alliance to other contexts (private benefits) crucially impacts its behaviour within the alliance, which might indeed deviate the client's allocation of resources from the theoretical optimal one in the absence of spillovers.

Finally, our theoretical analysis improves our understanding of buyer–supplier collaborative relationships. First, it extends the transaction cost perspective to analyse the impact of intangible RSIs on appropriability hazards, which have received less attention. Second, it highlights the importance of analysing separately tangible and intangible RSIs. Previous research by Hoetker and Mellewigt (2009) posed this issue by showing how each type of investment entails different hazards of opportunism and requires different governance structures. Our paper complements theirs by also highlighting the importance of taking into account the type of supplier investing in these specific assets.

IMPLICATIONS, LIMITATIONS, AND CONCLUSION

This study suggests that the success of R&D outsourcing relationships depends on the ability of the firm to manage the relationship to avoid undesired transfers of knowledge without putting in danger the performance of the outsourced task. When outsourcing a specific activity related to a firm's core competences, managers have to be aware of the fact that making intangible RSIs fosters communication and coordination among partners, which may improve productivity levels. However, these investments may also increase knowledge management complexity and intellectual property concerns. Given that alliances must be effectively managed for their benefits to be realized (Ireland et al., 2002), to gain the most from these investments, knowing how to manage knowledge transfer effectively (and the hazards originating within these alliances), to prevent the leakage of valuable knowledge becomes crucial. Obviously, the best way to manage these alliances would be to develop what Kale et al. (2000) call alliance capabilities, that is, skills that allow the firm to learn while protecting its proprietary resources. Firms with such capabilities are also prepared to make the most of outsourcing agreements for services requiring proprietary knowledge. This is the case because they can protect it without damaging the functioning of the alliance. In effect, our results provide empirical support for Larsson et al.'s (1998) argument that the way partners manage the collective learning process plays a key role in the success or failure of strategic alliances, as the opportunistic learning strategies followed by partners may undercut the collective knowledge development in the alliance.

The message of this study to technology managers is that they should take into account that even though these investments aimed at facilitating knowledge transfer may con-

tribute to the supplier performing more effectively thanks to coordination and communication improvements, their effectiveness may diminish if they are transferring proprietary knowledge that is closely related to the firm's competitive advantage to an external firm that may become a potential competitor. Thus, before passively letting suppliers make these investments, and the client responding with mutual investments, firms should carefully consider whether they are the ones who are going to take more advantage of these improvements in communication and governance, or whether it is the suppliers who may ultimately learn more than they should as a result of these investments (Zhang and Baden-Fuller, 2010).

Our study speaks to existing evidence showing that the R&D function can be sliced and disaggregated into several services or stages (Contractor et al., 2010), so that 'optimal MNE strategy is increasingly composed of control and location decisions implemented at the activity level, rather than the subsidiary level' (Mudambi and Venzin, 2010, p. 1512). Therefore, managers must carefully ponder not only which R&D services they decide to outsource, and to whom, but also their ability to manage those agreements properly, especially the inter-organizational learning process. Learning how to manage these agreements efficiently is crucial for remaining competitive and for being able to use R&D outsourcing as a tool for value creation. One critical aspect when crafting a firms' R&D outsourcing strategy is the fact that, if it is improperly implemented, it can lead to an erosion of the firm's technological competences; not only because of the misappropriation of the client's already existing know-how, but also because the client would not continue to accrue expertise and know-how in the activities outsourced. This last process of losing competitive edge in critical areas is labelled as 'hollowing out' (Mudambi and Venzin, 2010). Thus, despite the flexibility benefits that can be generated, too much outsourcing of knowledge-intensive activities could 'hollow out' the competencies of the client firm, especially if the firm lacks competency in terms of value chain orchestration (Kotabe and Mudambi, 2009). Firms lacking these managerial capabilities so as to be able to 'orchestrate' these disaggregated R&D processes will face a higher risk not only of erosion of their technological competencies but also of losing their competitive advantage. These managerial challenges call for further research on R&D outsourcing.

Limitations

Our study is not without limitations. Our data are cross-sectional, so we could not analyse all of the interrelated processes that may take place within the R&D outsourcing agreement. Although our sample is representative of the population of firms in the selected industries by country of origin and firm size, we obtained a low response rate, so our results should be taken with caution. While we have controlled for type of R&D service outsourced, project goals may vary depending on the type of service being outsourced; however, owing to our number of observations, it was not possible to segment our sample. Although we have adjusted the number of patents assigned to each firm by sector, we analysed firms' technological capabilities globally by identifying only their cumulative number of patents. Another limitation refers to the way we measure the level of proprietary core knowledge transferred, as we are aware that not all the knowledge that is firm-specific and difficult to articulate has to be necessarily core to the firm.

We could not collect survey data from the suppliers, which would undoubtedly have enriched the study. Finally, although we have controlled for self-selection regarding the choice of which services to outsource by the client firm, there might be a possibility of second-order selection effects arising from the fact that, having decided to outsource an R&D service, those suppliers investing in intangible RSIs are likely to be those that have the capabilities to benefit from them.

CONCLUSION

Intangible RSIs can constitute a double-edged sword because they may facilitate not only the client's goal fulfilment and the development of the relationship, but also undesired knowledge transfers, as they offer learning opportunities to providers. Because managing this trade-off becomes especially challenging when outsourcing R&D services, we analyse the contribution that intangible RSIs made by the R&D supplier have on the performance of the relationship from the client's perspective. Building on transaction costs theory and the relational view of alliances, we argue that their contribution will depend on: (i) the client's need to transfer proprietary core knowledge to the supplier; and (ii) the client's perception of the supplier's opportunities for exploiting the acquired knowledge outside the scope of the agreement. Overall, our results show that these investments appear to be very effective for the client when the supplier is a research centre, thus exhibiting a low risk of both becoming its competitor and/or exploiting the knowledge gained via the outsourcing relationship. In contrast, when outsourcing to business firms, the positive effect these investments have on alliance performance diminishes as the amount of proprietary core knowledge transferred increases. In these cases, the client's awareness of the higher appropriability hazards involved lead it to adopt stronger safeguards by limiting their own investments in complementary intangible RSIs, which have the drawback of reducing the value it can capture from the supplier's RSIs. In conclusion, our study shows how, because of the risk of technological leakage associated with supplier's intangible RSIs, client firms may deviate their behaviour by being less cooperative, lowering the contribution that these investments can have on the focal transaction.

Nevertheless, our study leaves ample opportunities for further research on understanding buyer–supplier collaborative relationships. We call for future research to take more explicit account of the importance of analysing separately tangible and intangible RSIs because each type of investment entails different hazards of opportunism. We also highlight the importance of taking into account the profit orientation of the supplier investing in these specific assets.

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NOTES

[1] To be effective and foster performance, a minimum amount of RSIs by both parties is always required. An R&D supplier may be willing to unilaterally make large intangible RSIs because it perceives positive spillover effects, but the effectiveness of these investments requires transparency on the side of the client. Being transparent entails the client making some relevant RSIs, because personnel from the client firm must dedicate some time to facilitate the transfer of relevant information.
[2] We appreciate an anonymous reviewer for this insight.
[3] Note that IPR protection in the foreign country is less relevant when it comes to explaining offshoring decisions, as firms can choose a location with strong IPR protection when necessary; it is thus an endogenous decision. Nevertheless, we have run our models including also a control for the effectiveness of the IPR system in the destination country, and we obtained the same results.
[4] A table with first-stage descriptive statistics and correlation matrix is available from the authors upon request.
[5] We thank an anonymous reviewer for raising this issue.
[6] The results of this robustness test are available from the authors upon request.
[7] The results of this robustness test are available from the authors upon request.

APPENDIX

Table AI. Distribution of survey responses by country of origin and industry

		Population of firms		*Mailed surveys*		*Received surveys*	
		n	*%*	*n*	*%*	*n*	*%*
	USA	3529	51.12%	2000	50%	81	45%
Origin	European Union	3375	48.88%	2000	50%	101	55%
	Austria	95	1.38%	56	1.40%	2	1.10%
	Belgium	43	0.62%	25	0.63%	2	1.10%
	Czech Republic	33	0.48%	20	0.50%	1	0.55%
	Denmark	38	0.55%	23	0.58%	0	0.00%
	Finland	54	0.78%	32	0.80%	0	0.00%
	France	373	5.40%	221	5.53%	9	4.95%
	Germany	1041	15.08%	617	15.43%	24	13.19%
	Greece	4	0.06%	2	0.05%	2	1.10%
	Ireland	29	0.42%	17	0.43%	0	0.00%
	Italy	854	12.37%	507	12.68%	32	17.58%
	Luxembourg	2	0.03%	1	0.03%	0	0.00%
	Poland	63	0.91%	37	0.93%	3	1.65%
	Portugal	22	0.32%	13	0.33%	1	0.55%
	Spain	157	2.27%	93	2.33%	9	4.95%
	Sweden	71	1.03%	42	1.05%	3	1.65%
	The Netherlands	35	0.51%	21	0.53%	1	0.55%
	UK	421	6.10%	249	6.23%	12	6.59%
	East Europe	40	0.58%	24	0.60%	0	0.00%

APPENDIX *Continued*

		Population of firms		*Mailed surveys*		*Received surveys*	
		n	*%*	*n*	*%*	*n*	*%*
Industry	SIC 28 (Chemicals)	1312	19.00%	760	19.00%	45	24.73%
	SIC 35 (Transportation Eq.)	2337	33.85%	1357	33.93%	58	31.87%
	SIC 36 (Electronics)	1635	23.68%	947	23.68%	40	21.98%
	SIC 37 (Machinery)	840	12.17%	487	12.18%	16	8.79%
	SIC 38 (Measurement Eq.)	780	11.30%	449	11.23%	23	12.64%

Table AII. Number of services outsourced by type of service and supplier

Type of R&D service outsourced	*Type of supplier*		*Total*
	Private company	*University or technological centre*	
Basic or fundamental research services (including drug discovery in the pharmaceutical industry)	8	12	20
Designing products or prototypes	16	1	17
Customized software development services	15	0	15
Designing production processes or technology systems	13	1	14
Applied or experimental research services (including clinical research in the pharmaceutical industry)	7	4	11
Testing and analysis services (includes verification of products or processes, drug testing, routine product testing, and quality control processes)	7	0	7
Designing and engineering system architectures	5	1	6
Scientific and technical support consulting services for actual or proposed R&D projects	4	2	6
Software implementation services to help your company to implement new software	1	0	1
Development of product/prototypes or new or improved technologies (including drug manufacturing in the pharmaceutical industry)	2	0	2
Total outsourcing agreements (n = 99)	78	21	99

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