

Outsourcing Knowledge Work: Professional, Domain, and Context-Specific Knowledge

(Over Time)

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Abstract

We seek to advance our understanding of outsourcing in knowledge work by examining the capabilities firms accumulate over time in three types of knowledge – professional, domain, and context-specific. We propose that suppliers can systematically develop superior expertise in professional knowledge (relative to internal client functions) by drawing on advantages in hiring and motivating talented professionals. Furthermore, we posit that prior outsourcing decisions influence the domain and context-specific knowledge held internally by firms, leading to path dependent patterns in outsourcing. Thus we develop a logic for capability development in knowledge that is based on governance differences in other transactions that are related to the focal activity. Drawing on research in the knowledge-based view, we additionally examine how firms’ abilities to better leverage complementarities between different types of knowledge will impact outsourcing decisions. We exploit a unique dataset on outsourcing in the patent legal industry to test our propositions; however, our work has implications for the outsourcing of knowledge work more broadly.

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In recent years business has been fundamentally reshaped by an increasing reliance on knowledge as a critical economic input (Grant 1996; Itami 1997; Kogut & Zander 1992). Even as knowledge-based business activities have become an increasingly important component of firm performance, a number of these activities are being outsourced to external suppliers. A large and burgeoning market for knowledge work in fields like information technology, product design, and research has added to already well established fields like law, consulting, and advertising. Most companies simultaneously undertake such knowledge work internally as well as outsource work to external suppliers. However, there is little understanding of what drives these decisions, especially in terms of the knowledge-based capabilities needed to perform the activities.

The knowledge-based view (KBV) of the firm (Kogut & Zander, 1992, 1994; Nickerson & Zenger, 2004) has developed to explain how the challenges around coordinating knowledge help explain firm boundaries. The key insight of the KBV is that advantages in transferring knowledge are the foundation of firms—complex routines, communication channels, and a sense of identity exist within firms, which facilitate the sharing of knowledge and are difficult to replicate across firm boundaries. While these insights have been useful, the focus has remained on the challenges of transferring or communicating knowledge as the main factor determining whether firms internalize or outsource knowledge-based activities. What has not been directly addressed in this literature is how the types of knowledge required and the firm’s capabilities in them play a role in outsourcing decisions.

Research adopting a capabilities perspective emphasizes that outsourcing is primarily motivated by the existence of superior knowledge capabilities among suppliers relative to the capabilities within the firm (Argyres 1996; Schilling & Steensma 2001; Madhok 1996; 2002;

hoetker 2005; Jacobides & Hitt 2005; Jacobides & Winter 2005). However, when capability perspectives are used, the origins of knowledge capability differences between firms and suppliers are often treated as a black-box (e.g. Mayer & Solomon 2006) or as an outcome of serendipitous prior experience (e.g. Argyres 1996; Leiblien & Miller 2003). In a recent theory paper, Argyres and Zenger (2008) propose that capability differences between firms may result from prior governance choices. Excessive outsourcing can “hollow out” a firm or build up a dependence on a particular supplier (Langlois 1992; Ring and Van de Ven 1994; Gulati 1995; Langlois and Robertson 1995) while excessive integration can hurt a firm’s competitive position if superior knowledge (and associated capabilities) exists in the market. These ideas provide an initial understanding of the dynamic forces shaping the development of firm knowledge, however, their implications for outsourcing decisions in knowledge work need to be more fully explored. Particularly absent from the extant literature is a clear articulation of how different types of knowledge influence firm capabilities and thus shape outsourcing decisions over time.

The current study makes four main contributions to this literature. First, we develop a theoretical foundation and taxonomy for understanding how different types of knowledge – namely professional, domain, and context-specific knowledge – lead to capability development and firm boundary decisions, particularly in the context of knowledge work. A cornerstone of our approach is that when the assets and activities involved are knowledge-intensive, capability and governance considerations are not necessarily distinct but part of the same calculus. Indeed, we propose that differences between firms and suppliers in the governance of one type of relationship, namely the employment of talented knowledge workers, will have an impact on their relative capabilities with respect to knowledge work, specifically on their professional knowledge capabilities.

Second, we examine the importance of path dependence in outsourcing choices. Both KBV and capabilities perspectives tend to focus on characteristics of the focal transaction in determining governance choice; but Argyres and Zenger's (2008) argue that (p. 8) "causality in the relationship between capability and boundary choice may be precisely the reverse of common articulations. Rather than today's integration choice reflecting yesterday's acquired capability, today's capability may reflect yesterday's integration choice." We draw on this rationale to examine how prior sourcing decisions influence the firm's accumulation of knowledge, and thus influence future sourcing decisions. We argue that decisions to outsource (or not) can be self-perpetuating by reinforcing the domain knowledge and/or context-specific knowledge capabilities of the firm.

Third, recognizing that different types of knowledge are used simultaneously and jointly in knowledge-based activities, we examine the interactive effect of professional, domain, and context-specific knowledge on the outsourcing of knowledge work. Prior research within the KBV suggests that firms may be more effective at leveraging complementarities between different types of knowledge internally than across firm boundaries (Kogut & Zander 1992 1996; Conner and Prahalad 1996; Nickerson & Zenger 2004), and we draw on this research to develop deeper insights into how these complementarities influence firm outsourcing decisions.

Fourth, we employ micro-analytic data from patent prosecution work to test the effects of different types of knowledge on outsourcing decisions. Testing activity-level predictions such as the ones proposed in this paper is generally challenging due to a number of constraints with data in other types of knowledge work. However, with patent prosecution data, many of these constraints can be overcome. For example, the scope of work entailed in patent prosecution is similar for all patents, which allows us to run relatively well-controlled "experiments" with each patent. At the same time, because patents disclose a paper trail of knowledge of different types, it is possible to

measure the key knowledge variables of interest to our research. Finally, large technology firms apply for hundreds or thousands of patents each year, which facilitates quite robust controls for firm and time-period effects that are often not feasible in other contexts. The use of these detailed data in the patent-prosecution context lays the groundwork for future research that seeks to test micro-analytic theories of firm capabilities based on knowledge. We complement these large sample analyses with unstructured interviews of managers, which enable us to corroborate and discuss the managerial implications of our findings.

THEORY AND HYPOTHESES

Prior characterizations of knowledge have emphasized either the tacit versus codified nature of knowledge (Polanyi 1966), the exploratory versus exploitative nature of search (March 1991), or the cognitive versus experiential nature of understanding (Gavetti & Levinthal 2000). However, these approaches provide little insight into what the focal knowledge is about, and the ability of firms to develop knowledge-based capabilities will likely depend on the content of the knowledge involved. Therefore, we identify three types of knowledge that are important for knowledge work and complement each other in the creation of economic value: (1) professional knowledge, (2) domain knowledge, and (3) context-specific knowledge.

Professional knowledge refers to knowledge in the primary area of professional work that knowledge workers are specialized and employed in. For example, this could be knowledge about law, software, engineering, business strategy (for management consulting), accounting, and so on. Within broad professional fields, there are also often sub-specializations, which may proliferate and grow over time, and eventually Balkanize into separate professions. *Domain knowledge* refers to knowledge about the real-world domains in which professional knowledge is applied to address practical business problems. For example, effective software work requires knowledge about the industry (healthcare, banking, government) and/or application domain (order processing, online

shopping, inventory tracking) for which the software is being written. Finally, knowledge work also requires varying degrees of *context-specific knowledge* about the circumstances within a firm that are specifically relevant to the focal activity. Context-specific knowledge can relate to many areas necessary to complete a specific knowledge activity, ranging from knowledge about the strategies and goals of the firm to knowledge about specific individuals, processes, assets, and technologies within the firm. Therefore, our characterization of context-specific knowledge corresponds closely to the Williamsonian condition of information impactedness, whereby valuable firm-specific knowledge is needed for performing a given task (Williamson 1975).

Our three-part typology of knowledge mirrors Castanias and Helfat's (1991) hierarchy of skills which identifies generic, business or industry-related and firm-specific skills as three types of critical management skill.² Our typology is similar in that we view professional knowledge (similar to generic skill) as being broad and easily transportable across situations, while context-specific knowledge (similar to firm-specific skill) may be harder to transport across different situations. Moreover, domain knowledge is analogous to Castanias and Helfat's (1991) industry-related skills in that these are essentially re-deployable from one firm context to others that are similar. However, our typology extends upon Castanias and Helfat (1991) in that our focus is not on top managers per se, but instead on the type of knowledge needed for the knowledge tasks accomplished by skilled professionals, regardless of hierarchical level. Our choice of labels for these types of knowledge further reflects the potential existence of both internal and external functions that may possess the same relevant knowledge.

While these three types of knowledge are conceptually distinct, all three are potentially implicated in any knowledge-based activity and it is also likely that they may complement each

² Castanias and Helfat (1991) build ultimately on Becker's (1964) pioneering work on generic and firm-specific human capital, and the stream of research that it has inspired over time.

other in the creation of economic value. Moreover, firms face different types of constraints and opportunities when attempting to develop professional, domain, and context-specific knowledge, which in conjunction with the characteristics of knowledge-based activities influences the outsourcing of knowledge work. Below we provide greater detail on how the attributes of each type of knowledge may influence the performance of knowledge work and thus shape firm outsourcing decisions.

Professional Knowledge

By virtue of how professional knowledge is developed we propose that external suppliers may systematically develop better professional knowledge capabilities than internal firm departments over time and that this will influence when and what type of knowledge-based work firms will outsource to suppliers. Specifically, suppliers may develop greater professional knowledge by virtue of their differential ability to attract, motivate, and retain a diverse pool of talented knowledge workers relative to intra-firm departments. The suppliers' labor market advantage is driven in part by their ability to provide a highly incentivized work environment, which attracts talent and rewards the development of expertise so that compatible knowledge workers gravitate towards suppliers rather than intra-firm departments. It is also supported by the variety of interesting and challenging work that suppliers can offer potential recruits, and by the opportunity to work alongside other experts with a wide range of experiences themselves. These may be motivators in themselves because of the learning and professional benefits they bring. It is surely challenging for external suppliers to service client firms while incurring the costs of arms-length coordination and knowledge exchange required for performing their tasks effectively, but this is offset by the premium they receive for their expertise. In turn, some of this premium is passed on to their employees in order to adequately reward and incentivize individual expertise development.

Intra-firm departments trade on their familiarity with the processes, technologies and strategies specific to the firm, and as such they tend to engage in a narrower range of activities than external suppliers. As a result, intra-firm departments are unable to reproduce similar incentive structures for the development of broader professional expertise. Client firms can try to attract talented employees by promising them interesting work as well as high pay, but they may be unable to fulfill such commitments because they face inherent difficulties in creating a market-like environment within the firm (Williamson 1985; Foss 2003). An example from our empirical context is patent attorneys. An internal patent attorney is likely to stay current only in narrow aspects of the law that affect their employer's technology (and may not have time even for that as they deal with various firm-specific issues), while patent attorneys for a top law firm will be current in many aspects of patent law because of the learning opportunities they have and the incentives they face.

Thus, suppliers end up accumulating a broader range of professional knowledge, and that knowledge attracts customers looking for such expertise, which leads in turn to more expertise development. Simultaneously, these supplier firms also attract superior talent based on their ability to offer diverse and challenging work at a premium wage, which further boosts their ability to accumulate professional expertise. This mechanism of positive feedback may lead to the sorting of professional knowledge between suppliers and clients, such that suppliers accumulate more expert professional knowledge than client firms.

We note here, and discuss further in our concluding section, that suppliers may not develop superior expertise under all conditions of knowledge-based work. Nor is it the case that all suppliers will be more expert than intra-firm functions. For example, many suppliers may get business (and firms may outsource to them) due to their lower costs or scale economies, their domain knowledge, or to smooth out internal firm workloads. Moreover, even when suppliers

have superior professional expertise, client firms may not always outsource because expert service is inherently expensive (as we note above) and potentially costly to coordinate. With regard to the latter in particular, the impetus to outsource for professional expertise must be balanced against the advantages of other complementary types of knowledge that may be held within the firm (Grant 1996; Kogut & Zander 1992; 1996; Somaya, Williamson & Zhang 2007).

Considering these constraints we propose that the incentives to access external expertise through outsourcing would likely be strongest in situations where the negative consequences associated with errors in the professional knowledge applied are large, or equivalently, where there may be a significant gain from using expert knowledge. We describe these situations simply as highly “consequential” knowledge-based activities (i.e., situations that are not necessarily related to competitive advantage, but rather instances when mistakes are highly costly).³ For example, in the legal field, companies may be highly motivated to utilize the expert knowledge of external law firms in situations where the perceived probability of litigation or legal liability is high. Similarly, companies may be more likely to hire reputable external management or information technology consultants to assist in the planning and execution of projects that have large financial costs and have great significance for the company.

H1: Firms are more likely to outsource more consequential knowledge work in order to access professional expertise available through market suppliers.

Domain Knowledge

The successful execution of a knowledge-based activity also requires an understanding of the domain in which the activity is occurring. Complex knowledge work generally involves tradeoffs between different task dimensions, and a good understanding of the application domain

³ We want to clearly separate strategic, firm-specific issues, which are a different type of knowledge that we will address shortly (when discussing contextual knowledge) from transactions with a high cost of failure but not related to competitive advantage (non-patent examples would include transactions on a firm’s data center or IT backbone).

is necessary to make such tradeoffs and exercise creativity. When (client) firms diversify into new areas, they may initially lack the in-house domain knowledge required to effectively perform in these areas. For example, even a firm with a strong IT department may not feel confident in developing a new type of software application in-house for a new domain area (e.g. a bank diversifying into online trading). As such, organizational decision makers face an important strategic choice: they may decide to rely upon the domain knowledge base of external suppliers or they may choose to develop the domain knowledge internally and only rely upon external sources in limited situations (Parmigiani 2007). While a firm may make a sourcing decision based on the relevant considerations at a given point in time (e.g. workload, staffing budgets, time pressures, transaction costs), this decision may also have a lasting impact on the development of firm domain knowledge over time, thus shaping how future knowledge-based activities are performed.

Organizational leaders may attempt to use external suppliers as a means to develop intra-firm domain knowledge. For example, firm personnel might work closely with a supplier in order to learn from that supplier. Thus, the use of suppliers may complement internal capability development in domain knowledge (Rothaermel, Hitt & Jobe 2006). However, there are several factors that may limit the effectiveness of this strategy in developing usable intra-firm domain knowledge. First, suppliers may not want to share their knowledge with the customer—they will provide the good or service, but not necessarily help their clients learn it so well that they could do it themselves. Second, domain knowledge may be difficult to learn due to issues of causal ambiguity, proprietary supplier technology, or other appropriability barriers. Overall therefore, it may be more difficult to transfer domain knowledge from suppliers to firms than within organizational boundaries (Darr, Argote & Epple 1995; Argote & Ingram 2000).

Finally, to the extent that knowledge is built up by engaging in learning by doing in a given domain (Arrow 1962), and requires constant improvement and updating, reliance on

suppliers creates and repeatedly replenishes supplier capabilities, with client firms continually playing catch-up. As suppliers develop greater familiarity with the firm and its technologies, any governance advantages the firm may have had in doing knowledge work internally also diminishes. Therefore, if a firm relies extensively on suppliers in a particular domain, then this may over time inhibit the firm from building up its own domain knowledge capabilities. Firms are thus likely to find themselves in an incompetence trap, where outsourcing knowledge work reinforces their lack of domain knowledge, leading to further outsourcing.

Alternatively, organizational decision makers may decide to develop domain knowledge capabilities within the organization. While firms may hire new employees and/or invest in training to partially address their domain knowledge needs, it may be difficult to develop such knowledge without the learning-by-doing opportunities afforded by actually engaging in knowledge-based work internally (Arrow 1962; Miller & Leiblein 2003). Domain knowledge capabilities developed through the sheer expedient of working in a particular domain may be particularly important in rapidly evolving domains; for example in patents, where the technology domains of patents are constantly changing due to the accretion of new discoveries. Therefore, if firms have developed domain knowledge capabilities through the internalization of prior knowledge work, they may be less likely to use external suppliers for current work in the same domain.

We note the contrast between our logic and two other views prevalent in the literature – first, that partial outsourcing may itself be a way for firms to gain knowledge (Rothaermel, Hitt & Jobe 2006), and second, that having strong internal knowledge capabilities may facilitate outsourcing by making it easier to find and monitor potential suppliers (Mayer & Salomon 2006). Apart from our distinction between domain knowledge and other types of knowledge, our rationale differs from these perspectives in highlighting the difficulties of learning from suppliers

in dynamic domains, and particularly in services (as contrasted with components) where each project typically requires new knowledge-intensive problem solving and therefore presents learning opportunities. Moreover, we focus on the first-order effects of having stronger knowledge capabilities as highlighted by Mayer and Solomon (2006), rather than second order ones that become relevant only for activities that involve complex contracting. Overall, therefore, we conclude that the outsourcing of knowledge-based work will be less likely when the firm has built-up relevant domain knowledge capabilities through prior internalization of knowledge work.

H2: Firms are less likely to outsource knowledge work in domains where they have built domain knowledge by previously internalizing knowledge work.

Context-Specific Knowledge

Sometimes knowledge-based activities are more closely tied to a unique technology, organizational unit, or strategic area that is specific to a firm. Even within the same firm, different closely-tied activities may be related to different firm-specific contexts (for example, different technologies, products, markets or divisions). In these cases, effective problem-solving for the completion of the activity requires significant context-specific knowledge so that the solutions generated by knowledge work effectively addresses firm needs. Knowledge-based activities needing high-levels of context-specific knowledge correspond closely to an information impactedness condition (Williamson 1975), whereby current activities build upon knowledge gained from previous work within the same firm-specific context.

External suppliers face distinct disadvantages, relative to internal departments, in the development of context-specific knowledge because they may not share a common language and/or relationships (and/or a sense of identification) with internal firm clients (Grant 1996; Kogut & Zander 1992; 1996). Moreover, because this type of knowledge has less value for other supply relationships, suppliers may be concerned about client opportunism and are therefore reluctant to

make investments in context-specific knowledge (Williamson 1975). While suppliers can be compensated to invest in the development of context-specific knowledge (for example, by paying for the time taken to learn what is needed), the cost of this investment makes external suppliers less attractive for servicing firm needs. Moreover, due to time compression diseconomies (Dierickx & Cool 1989; Knott, Bryce & Posen 2003), suppliers are typically unable to develop the same depth of context-specific knowledge as internal providers, and are consequently liable to provide less effective solutions for highly context-specific activities.

Finally, client firms may be reluctant to help external suppliers develop context-specific knowledge. A firm may be concerned that the supplier will take advantage of the fact that it is the only entity with the requisite context-specific knowledge needed to complete an activity (Williamson 1975). Moreover, to the extent that context-specific knowledge tends to have high strategic significance for the firm, concerns may arise that outsourcing the activity to suppliers can create appropriability and monitoring issues (Mayer and Nickerson 2005). Even if the supplier itself is not a direct competitor, the firm may nonetheless be concerned that the supplier might use what it learns to help other clients who are potential competitors. This would further hamper the free flow of information between client and supplier, and make outsourcing less effective.

While any given activity may suggest internalization when its associated need for context-specific knowledge is evaluated in isolation, buyers and suppliers generally have longer histories with outsourcing than a single transaction. Argyles & Liebskind (1999) refer to governance inseparabilities, whereby outsourcing choices made for one activity affect the choice set or the relative costs of future options. Because governance choices may be linked inter-temporally in this way, examining one decision alone can lead to incomplete and potentially erroneous conclusions. Thus, even if a particular activity has a high need for context-specific knowledge as indicated by a high volume of prior related activities of the firm, suppliers may already have

developed this knowledge if those closely related activities had also been outsourced. Moreover, the outsourcing of prior related activities may also mitigate appropriability concerns due to the deployment of relational governance mechanisms and the development of a certain level of trust between the parties (Gulati 1995; Uzzi 1996). By contrast, if closely related activities were internalized in the past, this would have built-up context-specific knowledge among internal service providers within the firm, and simultaneously limited both the build up of such knowledge and the institution of relational governance mechanisms with external providers. Consequently, only the volume of related activities that were internalized in the past should be associated with an increased probability of internalization in the future.

H3: Firms are less likely to outsource knowledge work the greater the amount of prior contextually-related knowledge work was performed internally.

Interactions Between Knowledge Types

When performing knowledge work, all three types of knowledge discussed above are likely to be used in an interdependent manner. For example, the activity of prosecuting a patent simultaneously requires expertise in the law and processes of patents (professional knowledge), awareness of technical developments and other patents in the technological domain of the patent (domain knowledge) and often an understanding of the role played by the focal patent within the related context of the client firm (context-specific knowledge). Similarly, for developing a good software system for inventory management, a firm needs software development skills (professional knowledge), an appreciation for the issues involved in inventory management (domain knowledge), as well as knowledge about how the inventory system will be used within the specific firm (context-specific knowledge). It is likely that for a given knowledge-based activity the focal firm may possess different levels of professional, domain and firm-specific knowledge, and that each type of knowledge may be more or less relevant. For example, in some

(consequential) activities professional knowledge may be important and available at a superior quality from expert suppliers, but the focal firm may also possess high levels of relevant domain and context-specific knowledge. Identifying how these different combinations of knowledge types influence decisions to internalize versus outsource knowledge work would be a valuable addition to our understanding of how knowledge-based activities are performed by firms.

Because the focal knowledge-based activity requires the simultaneous use of all three types of knowledge, the problem of performing the activity effectively is essentially non-decomposable (Simon 1962). Consequently, within-firm organization has significant communication and coordination advantages in combining these different types of knowledge, provided of course that each type of knowledge is available within the firm (Arrow 1975; Kogut & Zander 1992; 1996; Conner and Prahalad 1996; Nickerson & Zenger 2004). Simply put, firms can more effectively leverage complementarities between different types of knowledge if the activity is performed internally than across organizational boundaries. In Hypothesis 1 above, we explained that suppliers are likely to have greater expertise in professional knowledge, creating an impetus to outsource more consequential knowledge-based activities. However, the preference for outsourcing highly consequential activities may vary based on the levels of relevant domain or context-specific knowledge possessed by the firm. Firms may view the professional expertise of suppliers as less meaningful because of their own superior ability to combine their own (even potentially weaker) professional knowledge with complementary domain or context-specific knowledge, when these are present internally at high levels. Conversely, if firms possess low levels of domain and/or context-specific knowledge they may be more likely to rely on the professional expertise of external suppliers. Thus, the tendency to outsource consequential knowledge-based work may be negatively moderated by the level of domain and context-specific knowledge a firm possesses.

Hypotheses 4a: The tendency for firms to outsource consequential knowledge-based activities to access suppliers' professional expertise will decrease the more a firm has developed domain knowledge by previously internalizing knowledge activities.

Hypotheses 4b: The tendency for firms to outsource consequential knowledge-based activities to access suppliers' professional expertise will decrease the more a firm has developed context-specific knowledge by internalizing prior related knowledge activities.

A similar logic may apply when firms have different levels of domain and context-specific knowledge relevant to a particular activity. If both domain and context-specific knowledge held by the firm is low, it has little reason not to outsource the activity. However if the firm possesses high levels of either type of knowledge, then there is a significant impetus to internalize the activity, not only because of the knowledge itself but also because of the opportunities to leverage efficient internal coordination between different types of knowledge. In other words, the contribution of strong context-specific knowledge towards executing knowledge activities is enhanced by its more effective coordination within the firm with even weak firm domain knowledge, and vice versa. Increases in domain knowledge may lead to a greater reduction in the attractiveness of external suppliers when context-specific knowledge is low, as opposed to high. Put slightly differently, because firms have an advantage in coordinating different types of knowledge internally, a decrease in firm domain knowledge will have a bigger positive impact on the likelihood of outsourcing when its context-specific knowledge is also low (as opposed to high), and vice versa. Of course, if both domain and context-specific knowledge are high (low) within the firm, the overall (as opposed to the change in) likelihood of outsourcing would be lower (higher) than if either type of knowledge were high (low).

Hypotheses 4c: The firm's context-specific and domain knowledge will negatively moderate each other's tendency to increase the internalization of knowledge work.

DATA AND VARIABLES

Sample

We tested our hypotheses by examining the patent outsourcing decisions of a sample of technology-based Fortune 500 firms over the period 1990-1995. Our sample included all (128) public U.S. firms in the 1989 Fortune 500 survey (published in 1990) from the following five technology-based industries: chemicals (39 firms), computer manufacturing (22 firms), electronics (40 firms), pharmaceuticals (12 firms) and scientific and photographic equipment (16 firms). Our sample focused on those industries in which firms were most likely to file for and obtain patents. Using the Directory of Corporate Affiliations, we gathered information about the entire corporate family (all subsidiaries and divisions) for each firm in each year of our dataset. We then matched these various corporate business units with the unique patent assignee codes used by the U.S. patent and trademark office (USPTO), and obtained all patents filed by (or issued to) these firms during the period 1985-1995. In essence, we reproduce the approach adopted for the NBER patent dataset (Hall, Jaffe & Trajtenberg 2001) albeit at a much more detailed year-by-year level for a smaller sample of large firms (the NBER dataset is based on a single-year [1989] concordance between business units and assignee codes). Only the years 1990-95 are included in our analyses, but data from prior years is used to code some of our variables.

Based on this approach, we identified a total of 80,129 patents filed over six years (1990-95) that form the core of our analysis, though our complete dataset (including prior outsourcing decisions that we use to code some variables) comprised a little over 145,000 patents. Financial data on the companies in our sample were collected from Compustat / Research Insight, but these data were only used in secondary analyses. Our primary empirical analyses conservatively employ fixed effects at the company-quarter level, and thus already account for any secular quarter-to-quarter differences within firms including financial characteristics and staffing levels.

We use data included on the front page of each patent in the “Attorney or Agent” field to identify whether or not the patent was outsourced (see below). In order to code the affiliation of patent attorneys (or agents) listed on the patent, we employed multiple years of data on registered patent attorneys published by the Office of Enrollment and Discipline (OED) located within the USPTO. Patent attorneys are highly specialized knowledge workers, who are required to have a technical background (typically a bachelor’s degree in engineering or science) and pass the patent bar before they are registered. Only registered patent attorneys may practice before the USPTO, and maintaining a current address with the OED is a requirement for registration. Additional data on each patent were collected and coded from various datasets made available by the USPTO.

Variables

The dependent variable in our analyses is an indicator variable, *Outsourced*, which is coded as 1 if the “Attorney or Agent” field on the patent lists a law firm or external attorney, and as 0 otherwise. In many patents, the focal Fortune500 company’s attorneys are listed in this field, who can be identified from the OED attorney roster, so these patents were clearly not outsourced. In most outsourced patents, the “Attorney or Agent” field lists the name of a specific law firm, usually without the names of attorneys who worked on the patent. In less than 10% of outsourced patents the field lists attorneys employed by a law firm or in private practice, which we identified from the OED attorney roster. In about 12.7% of patents, the field is blank. We report results by dropping these latter patents from our sample, but we also estimated models by including these patents and coding them as not outsourced, and obtained similar results. All coding of the *Outsourced* variable was done by hand because it was difficult a priori to be certain about the variety of entries likely to be encountered in the “Attorney or Agent” field. Though labor intensive, hand coding of this variable was extremely reliable as it was possible to categorize entries quite easily by simple visual inspection and comparison with the OED attorney rosters.

In Hypothesis 1, we propose that more consequential activities are likely to be outsourced in order to access the professional expertise of market suppliers. The ultimate goal of patent prosecution is to obtain a watertight intellectual property right with economically valuable scope, and both validity and scope of a patent are almost always challenged if it ends up in litigation. Therefore, patents that may be challenged in litigation (or in litigation-related negotiation and licensing discussions) are particularly likely to be perceived as consequential, and therefore requiring expert handling. In our interviews (see discussion), company general counsels highlighted the importance of litigation-related patents and noted a preference to have them handled by experts. At the time of patenting, patents that are related to previous litigation are likely to be viewed as being at risk of litigation themselves. Therefore we test H1 by using the dummy variable *Consequential Activity* (coded as 1 if the focal patent cited a patent that was litigated in the past). We collected patent litigation data from the LitAlert database compiled by the U.S. Patent and Trademark Office based on reports from U.S. District Courts, and combined this with (much fewer) patent cases from the Section 337 forum of the International Trade Commission, which is an alternative forum for (import related) patent disputes in the U.S.

We coded a variable *Firm Domain Knowledge* (H2) to measure the extent to which the company has developed knowledge in the technical domain of the focal patent by previously engaging in patent prosecution work in-house. Specifically, we measure the number of prior patents processed internally by the firm in the same 7-digit International Patent Classification (IPC) as the focal patent. The IPC has several advantages over U.S. Patent Classification (USPC), the most notable of which are the unambiguous technological basis for IPC classes and the nested nature of the IPC system (see Lerner 1995). Using the IPC ensures that each patent class maps well to a narrow but coherent technological sub-field (e.g. A61K 038/xx: Medicinal preparations containing peptides). We restricted our measure of *Firm Domain Knowledge* to patents applied

for or issued over the previous 5 years (from the focal patent's filing date) to account in part for the obsolescence of knowledge over time, and to economize on the resource demands of coding. We reproduced our results using a 4-digit level of IPC aggregation and a 3 year "capture period," giving us some confidence that our findings are not sensitive to these definitions.⁴ Because we expect the acquisition of domain knowledge from each additional internalized patent to become progressively smaller, and because this variable (like others below) is very skew, we logged it.

We measured *Firm Context-specific Knowledge* for a given patent (H3) by the (logged) number of patents the focal patent cites that were issued to the same company and were processed in-house. As reflected in our theoretical discussion, these self citations indicate related prior knowledge activities that were internalized within the firm, therefore leading to the development of firm context-specific knowledge. Like our domain knowledge variables above, we measure this variable over the prior 5 years (see footnote 3).

In addition to these independent variables, we also coded a set of patent level control variables. We focus on controls at the patent level because both inter-firm cross-sectional variation as well as quarter-to-quarter intra-firm variation is already accounted for by our use of firm-quarter fixed effects (see below). Naturally, it is the attributes of the patent that play the biggest role in outsourcing decisions among patents applied for by the same firm in the same quarter. We use *Prior Outsourcing in Knowledge Domain* to measure the (logged) number of same-IPC patents that were outsourced (over the previous 5 years) by the company. Note that this is the analog of our *Firm Domain Knowledge* variable, except that these patents were outsourced

⁴ The 5-year capture period for other variables (see below) were also robust to 3-year alternatives. In addition, our analyses seem to confirm that there are diminishing returns to older knowledge. The additional marginal effect on the probability of outsourcing from (domain and context-specific) knowledge accumulated in the fourth and fifth years was insignificant. Similarly, we find that the additional marginal effect of domain knowledge in the broader 4-digit class (in addition to the narrower 7-digit class) was quite small, albeit significant. Therefore, the levels of aggregation we have chosen appear to be reasonable, both in terms of patent classes and prior years of experience, and moreover they are robust to changes in specification.

rather than being processed internally. It is unclear what effect prior outsourcing in the same domain will have on future outsourcing decisions. Exposure to the technology area may help the company develop domain knowledge that facilitates internalization of activities within the same domain in the future. On the other hand, prior outsourcing may also reinforce domain knowledge among suppliers, and in essence squander opportunities for firm domain learning, which can entrench pressures for future outsourcing. We also employ *Prior Related Outsourcing* – an analog of our *Firm Context-specific Knowledge* variable – that measures the (logged) number of self cited patents that were outsourced to external service providers (over the previous 5 years), with similarly ambiguous priors about our findings.

Furthermore, we include the control variables *Foreign inventor* (if the first listed inventor is based outside the U.S.), *No. of patent classes* (the number of distinct 3-digit U.S. patent classes for the patent), and *Forward citations* (a logged count of citations to the focal patent from subsequent patents) in our analyses. Because *Forward citations* are truncated by the number of years of data available after the patent issued, we face a potential bias in measuring this variable. Put simply, patents issued earlier will on average have more citations merely because they have had more time in which to be cited. We therefore obtain an unbiased estimate of *Forward citations* (for 15-years from the issue date of each patent) by applying a correction factor from the citation function (versus time) for the average patent in each technology class (see Hall et al 2001 for more details). Finally, we code a set of six technology grouping dummy variables using a USPC-based classification scheme widely used in prior research (Jaffe, Fogarty, & Banks 1998). Specifically, the groupings we use are *Chemicals, Drugs & Medical, Electrical & Electronics, Computers & Communications*, and *Other* (with *Mechanical* as the reference category).

ANALYSES AND RESULTS

Each observation in our data is at the level of a patent, for which we need to model the dichotomous firm decision whether or not the legal patent prosecution work is outsourced to an external supplier. While our dataset is longitudinal, spanning several years for each firm, it is not a panel dataset of firm-year observations. Further, because our companies typically filed for multiple patents in even a short time period like a (3-month) quarter, this provides a unique opportunity to account for all company-level factors (within each quarter) and examine only the variation between patents filed by the same firm within the same quarter. Therefore, we adopt a fixed effects model with firm-quarter fixed effects. While Logit and Probit approaches are well-developed to model binary outcomes, the conditional fixed effects Probit estimator is biased. Therefore, we employ the conditional fixed effects Logit estimator to analyze our data.

A firm-quarter fixed effects model renders a very conservative test of our hypotheses because it accounts for inter-firm and within-firm temporal heterogeneity, and thus rules out many alternative explanations. For example, any firm-level factor – such as financing, staffing, or strategy – that may affect outsourcing from quarter to quarter would be accounted for, and the model essentially leverages the differences between patents filed by firms within the same quarter to estimate coefficients. This automatically means that we may lose some observations. For example, if a firm does not outsource any patents (or outsources all) in a given quarter we cannot use data from this firm-quarter because idiosyncratic firm-level drivers of outsourcing in that quarter cannot be separated from patent-level drivers. Consequently, an additional 13% of our observations drop out of the sample, leaving us with a final set of 59,590 observations.

Table 1 provides descriptive statistics of our data, split up by the sub-samples of patents that are outsourced and internalized. The differences in the means of our key independent variables between the two sub-samples are consistent with our hypotheses. The data also shows substantial within unit (firm-quarter) variation, indicating that the patent-level differences are

large. We report a correlation table (Table 2), which shows limited correlation across our key variables. In particular, the low correlation between domain and context-specific knowledge is reassuring, indicating that the empirical overlap between these two constructs is quite low.

[Table 1 and Table 2 about here]

Table 3 presents our main results from the firm-quarter fixed effects Logit model. Model 1 includes only the control variables, whereas Models 2-4 add each of the proposed main effects sequentially and Model 5 includes all main effects simultaneously. For ease of interpretation, the estimates are reported as odds ratios, with a null value of 1 (rather than zero). Table 3 shows that the main effects predicted by Hypotheses 1, 2 and 3 were all supported at the 1% level of significance. Moreover, the magnitude of the relationships between the independent variables and the odds of outsourcing a patent are quite large. For example, based on model 5, a consequential patent (in the domain of litigation) has 16% higher odds of being outsourced relative to one that is not consequential (Hypothesis 1). Consistent with Hypothesis 2, a one standard deviation increase in the firm's domain knowledge (stemming from prior internalization of work in the same domain) is associated with 44.3% lower odds of outsourcing. Similarly, a one standard deviation increase in the firm's context-specific knowledge (as measured by internalized related patents) decreases the odds of outsourcing by 16.8% (Hypothesis 3). Interestingly, we find that *Prior Outsourcing in Knowledge Domain* and *Prior Related Outsourcing*, the analogous variables to firm domain and context-specific knowledge that measure prior outsourcing rather than internalization, were associated with statistically significant (1% level) increases in the odds of outsourcing.

[Table 3 about here]

Hypotheses 4a, 4b and 4c predicted that professional, domain and context-specific knowledge would have interactive effects on firms' outsourcing decisions. The tests of these interactions are provided in Model 6 of Table 3, which are also similar to the (unreported) tests for

each interaction separately. Consistent with the predictions of Hypothesis 4a, the interaction between consequential activity and firm domain knowledge was negative and significant (at the 5% level). However, the interaction between consequential activity and firm context-specific knowledge was not significant, thus Hypothesis 4b was not supported. Finally, consistent with the predictions of Hypothesis 4c, there was a significant and positive interaction between firm domain knowledge and context-specific knowledge.

Interpreting the magnitude and direction of change implied by interaction terms can be tricky in Logit (and other choice) models due to the non-linear character of these models (Huang and Shields 2000). Therefore, we follow recommended best practice (Hoetker 2007) and evaluate the joint impact of variables in the two significant interaction terms at representative high and low values from our data (Figures 1 and 2). The chosen values of the variables are briefly discussed in the notes accompanying the figures. In each figure, there are two sets of graphs, one representing the estimated impact in terms of odds ratios and the other in terms of probabilities.⁵

[Figures 1 and 2 about here]

Hypothesis 4a predicted that the tendency for firms to outsource consequential knowledge-based activities would diminish with higher levels of a firm's domain knowledge. Consistent with this prediction, Figure 1 illustrates that when firms had high (as opposed to low) levels of domain knowledge they were considerably less likely to outsource the filing of consequential patents (i.e., patents that cite previously litigated patents), compared to inconsequential ones. In fact, when firm domain knowledge is high, Figure 1 indicates an attenuation of the tendency to outsource

⁵ In logit models, the effect of a change in a variable on the probability (but not odds) of choosing an alternative depends on the values of the other variables, or equivalently on the baseline probability estimated from the other variables. In the graphs that show the joint impact of variables on the probability of outsourcing, we assume the baseline probability to be 0.3 (which is very close to that of the sample on average). It should also be noted that unlike in regression models (or for odds ratios), the estimated impact on probabilities at intermediate values of the variables do not simply lie on the straight lines connecting the high and low levels in the bar charts. Rather the relationship is curvilinear.

consequential activities almost to the point that this relationship disappears (but is not reversed). Hypothesis 4c predicted that firm domain and context-specific knowledge would interact such that the impact of either variable on the tendency of firms to internalize knowledge-based activities would be lower when the other was also high (as opposed to low). The results reported in Figure 2 provide support for this prediction. Put differently, firms were more likely to outsource patent prosecution when they possessed low levels of both domain and context-specific knowledge, compared to the cumulative independent effects of low levels of each type of knowledge. In this case, the main effects of both variables persist even at high levels of the other variable.

DISCUSSION

In this paper we introduced a taxonomy consisting of three main types of knowledge – professional, domain, and context-specific – entailed in knowledge-based work and explored the role played by each on the decision to outsource knowledge-based activities. Our analysis produced several key findings. First, we found that the decision to outsource knowledge-based work is influenced by how consequential the activity is, whereby firms preferentially outsource highly consequential knowledge work to access professional expertise that suppliers may be systematically more effective at developing. A second key finding of our study is that outsourcing decisions are heavily influenced by the path dependent accumulation of capabilities in domain knowledge resulting from prior firm choices about outsourcing (Argyres & Zenger 2008). Third, we also find evidence that when activities require higher levels of firm context-specific knowledge, and this knowledge has been retained within the firm through internalization of related knowledge-based activities, this may disadvantage suppliers compared to internal functions and reduce the motivation to outsource.

A fourth important finding of our research is that these different types of knowledge have an interactive effect on firms' decisions to outsource knowledge-based activities. Specifically,

while firms have a tendency to outsource highly consequential knowledge-based activities, this tendency is considerably reduced when firms have developed internal stocks of domain knowledge. Similarly, the tendency of firms to outsource when they lack domain knowledge is diminished when they have high levels of context-specific knowledge, and vice versa. Overall, we find that when firms possess high (as opposed to low) levels of one type of knowledge (e.g. domain or context-specific) they are less likely to outsource due to a lack of other types of knowledge.

To reinforce our empirical results and add additional insight into outsourcing decisions in knowledge work, we draw on unstructured field interviews with retired general counsels from six different firms in our sample. The interviewees were asked to explain when and why they outsourced patent prosecution work in their companies. In two cases, the general counsels referred us to the company's chief patent counsel, and for those companies our interview responses below reflect primarily the opinion of the chief patent counsels. Six of these executives had built their careers as patent law professionals, and all eight had direct experience in administering and supervising the patent law function at their companies during the 1990s. We conducted these interviews at the beginning of our research and revisited the transcripts after conducting the empirical analyses. We discuss our main findings along with our interviewees' insights about patent outsourcing decisions in the discussion below.

Professional Expertise

In this paper, we proposed a logic whereby there is a sorting of professional expertise into suppliers on account of their ability to aggregate diverse learning opportunities from multiple clients and attract and reward highly motivated expert professionals, leading to a virtuous cycle of professional knowledge development. However, hiring external suppliers (law firms) is costly, both in the organizational costs of coordinating with them and in the pecuniary costs of paying for

expert service providers. To illustrate, consider the following comments from our interviewees (labeled anonymously A-F).

(A) "... to educate them from the beginning the concept of what you do and the prior art and all the rest of the kinds of things ... to get somebody to come in and do that from the outside ... its very expensive, to just come in and learn without having to ... you know ... produce."

(B) "The reason you don't go out to an outside patent firm unless you absolutely have to is because it's too expensive. The patent lawyers, I mean they're just voracious! Have you talked to patent lawyers? They're absolutely horrible. They're so expensive. They're few of them, their skills are much in demand, and the good firms are really very very good, and then they price accordingly. ... you do as much in house as you can. It's cost effective."

(C) "Well, that is a way to do it, is to have an outside law firm, but that's a more expensive way to do it. ... in terms of long range factors that is not the most economic way to go."

(E) "generally patent attorneys in house, can be retained at a lower cost per task ... we're not carrying the burden of marketing, and some of the productivity and cost effectiveness shortfalls the law firms have, and we can produce in house cheaper because of that ..."

While acknowledging the inherent costs of coordinating with and retaining external service providers (reflected in all the comments above), note how one of our interviewees (B) explicitly recognized that law firm fees reflect the value of their professional expertise. Our empirical results provide strong evidence that this expertise is an important driver of outsourcing decisions when the focal knowledge-based activity is perceived to be more consequential. Specifically, when closely related patents were involved in prior litigation, prosecution of the focal patent was more likely to be outsourced. Consistent with this logic, a number of our interviewees highlighted the value of supplier expertise for highly consequential patent prosecution work, which in their view was typically connected with patent litigation.

(A) "[You outsource ...] If you have a special situation ... oh I don't know, something related to litigated matters or something related to you are in litigation and you are in development within the scope of litigation ... in general I think it works much better inside [the company]."

(B) "... it's all based on the speculation that you may be sued or may wish to sue. And in that circumstance, why of course you go out, you hire the best you could and you pay the fees, and you're happy that those people are available to work for you, and are willing to."

(E) “That having been said [referring to the lower costs of internal work], you go outside ... for expertise, and there are certain technical areas, there are certain processes and functions of the practice of patent law that are unique enough that you would go out for expertise. There are certain things that are at a high enough level of importance, that you want to pay the extra buck to get the best there is. ... [because] you lose a lot of other revenue if you get beat [in litigation], you may go outside just to cover yourself, to only get the best. ... It would be legal expertise, it would be someone who had been there before.”

Not surprisingly, a number of our interviewees also expressed the view that outsourcing is often used to smooth out work loads, catch up with backlogs, or when client firms (such as start-ups) have inadequate scale in patenting needs to support an internal patent department. Consequently, it is clearly not the case that every patent law firm trades on its professional expertise. One interviewee (F) even described suppliers (specialized patent law firms) that had taken conscious steps to lower costs and worked closely with their clients to become cost-effective alternatives to internal patent departments. Nonetheless, taken together, our empirical findings and qualitative interviews suggest that superior professional expertise residing in external suppliers may play an important role in the decisions of client firms to outsource knowledge-based work. Furthermore, these decisions to outsource for professional expertise appear to be driven by the perceived importance or consequence of the focal activity.

Domain Knowledge

Our results also suggest that outsourcing decisions were influenced by how firms have developed internal domain knowledge in the past. In particular, we found that firms were less likely to outsource a patent the more they had previously internalized patenting within the patent’s specific technology domain. Conversely, our results also suggest that if firms previously outsourced their same-domain patents, they may suffer from an “incompetence trap,” whereby suppliers develop and maintain a domain knowledge advantage relative to client firms that the latter are unable to bridge. Therefore, initial decisions to outsource (or not) may lead to a trajectory over time that creates heterogeneous capabilities between firms and their suppliers.

Consistent with the resource-based view, these heterogeneous capabilities would not be sustainable without effective barriers to imitation (Barney 1991; Wernerfelt 1984), which in this case may be largely provided by the costs of learning by doing and the time compression diseconomies entailed in catching up with the knowledge frontier (Dierickx and Cool 1989). Two of our interviewees in particular highlighted the role played by domain knowledge in outsourcing, and shared their views on how this knowledge is created, shared, and sustained in both supplier and client firms.

(B) “[we outsourced] ... if it was in an area where we felt we needed the [domain] expertise that we did not have in house. Initially, we didn’t have patent attorneys with a biotechnology background – it was a new area. We recognized very rapidly that we needed someone [a patent attorney] that had that biotech background to work in that area. [Question: so you recruited someone?] We recruited someone, but initially we went outside to do the work.”

(F) “So you may find in a large company that half the patent application work is being sent to outside counsel, who in turn are people who are specialists in their technological fields and they can write patent applications efficiently because ... presumably if they really worked in the same area for a long time they really know the subject matter. ... Oftentimes, if there is [domain knowledge] expertise in a particular area in a law firm it will likely spread from one attorney to another and so on. So there might be a group of folks who are pretty good in a certain technology. So that might come about if say business increases from a particular corporate client.”

Taken together, we believe our findings provide compelling initial evidence that the outsourcing of knowledge-based activities is not a static process, but instead shaped by dynamic path dependent processes of domain knowledge development resulting from prior outsourcing decisions (Argyres & Zenger 2008). In addition, our interviews highlight a potential role for firm strategic actions to break out of incompetence traps, or supplier actions to lure firms into one. We should also acknowledge here that client firms may sometimes be amenable to having suppliers who develop and maintain the needed domain knowledge. However, a systematic investigation of these questions awaits future research.

Context-Specific Knowledge

An important finding of this research is that the specificity of focal knowledge activities to contextual conditions within the firm influences outsourcing decisions. The governance and coordination logics of TCE and KBV, respectively, would suggest that such information impactedness would lead to a decreased likelihood of outsource knowledge-based activities. However, we found in our analyses that this was only true when the prior related activities of the firm were also internalized. Our interviewees noted a number of potential obstacles to outsourcing activities that are more contextually specific to the firm, including the transaction cost inefficiencies of sharing such knowledge, the communication barriers across organizational boundaries, and potential appropriability concerns. While none of our interviewees specifically highlighted the need for *internal* context-specific knowledge, their comments appear to assume that such knowledge would be available in-house.

(A) “If they have to contract out then there is another relationship that has to be worked out and that’s between inside attorneys and outside attorneys, and that tends to breed some barrier ... you don’t want your clients [firm R&D] to be talking to these outside guys and not talking with you ... and so on.”

(E) “ ... our [internal] patent attorneys are more efficient because they know the client and the know the product, and they don’t have to learn things on a new job.”

(F) “In the high tech business ... if it is [the company]’s business for example, its also going to be somebody else’s business ... because you know who your competitors are [acknowledges potential for knowledge leakage and conflict of interest]. ... Usually, we would try to keep the most important (sic!) patent applications in-house. Because they often called for a lot of back and forth between the engineers and the patent lawyers ... and the business people. ...”

External versus Internal Coordination of Knowledge

Our results also provide evidence that, consistent with prior theoretical arguments (Arrow 1975; Kogut & Zander 1992 1996; Conner and Prahalad 1996; Nickerson & Zenger 2004), important complementarities between different types of knowledge may be harder to exploit across firm boundaries than through internal coordination. Thus, we found that when firms possessed high levels of even one type of relevant knowledge, this internal knowledge negatively

moderated the proclivity to outsource due to a deficit in other types of knowledge. For example, when the firms' own domain knowledge capabilities were high, the tendency to outsource more consequential activities to access suppliers' professional expertise was almost completely attenuated. Similarly, the increase in firms' likelihood of outsourcing knowledge-based activities due to lower context-specific knowledge was lower at high (as opposed to low) levels of firm domain knowledge, and vice versa. Therefore, the more effective coordination of different knowledge types within the firm has the effect of increasing the disadvantages external suppliers face relative to internal departments when the firm has strengths in at least one type of knowledge. While we did not ask our interviewees directly about these differences in the coordination of knowledge, one interviewee independently offered some potential insights into these issues when discussing the advantages of outsourcing for accessing supplier professional expertise.

(B) "Actually you spend more time educating the outside patent attorney on [R&D] work that we were doing in-house, and then he would basically take our efforts and then write it up in the form of a patent application. We would do the basic groundwork and then turn the work over to them, and then they would just put the bells and whistles so to speak on the patent application. Quite often, we would help write most of the application – for example, the "examples" that went into a pharmaceutical patent application, we would prepare it in-house and then turn it over to the outside person who would then incorporate it into the patent application ... The draft would come in to the patent attorney who was responsible for the [technology] area, and then he would look it over ... and then he would turn it over to the scientist to read, and quite often the scientist would be unhappy ... for one reason or the other, and we would have to do it again in-house or send it back to the outside law firm. ... which took a lot of time ... of the inside patent attorneys."

Consistent with our quantitative findings, these comments suggest that there is a significant need for coordinating different types of knowledge – the professional expertise of suppliers with firm domain (scientific) and context-specific (firm-related) knowledge in this case – for effective performance of knowledge work, and moreover, that this coordination is quite cumbersome across firm boundaries. Indeed, this interviewee opined that there "wasn't any time saving at all" (for internal staff) from outsourcing patent work, because of all the coordination involved.

Nonetheless, the same interviewee also acknowledged that accessing supplier professional expertise and a lack of firm domain knowledge were important reasons to outsource knowledge work generally. Therefore, one critical factor diminishing the attractiveness of external suppliers is the amount of firm-supplier communication and coordination of different knowledge that is sometimes needed.

Limitations and Future Research

While our findings hold important implications for our understanding of the outsourcing of knowledge-based activities, this study is not without limitations, which may also provide valuable opportunities for future research. Let us begin by noting some important characteristics of patent legal work, which may have implications for the generalizability of our findings to other types of knowledge work. First, patents are usually prosecuted by individuals or small (2-3 person) teams, and the actual work falls wholly within a single profession (patent law), so that there are few challenges of organizational coordination across large teams of individuals or across functional areas. Second, while patent work is an important support activity and perhaps a valuable complementary capability for technology firms, it does not, in and of itself, confer significant competitive advantages to these client firms (only to patent law firms). Patent work is thus unlikely to be an independent source of rents for the firm, which differentiates it from more strategic knowledge-based activities such as, say, product development or marketing. Third, there is a vibrant market for patent legal services arising from demand outside the focal firms in our study, which is also the case with many other types of knowledge based activities (e.g., IT, HRM), but not always so. Last, but not least, patent services appear to require “moderate” levels of specialized domain and firm-specific knowledge, so these types of knowledge are not determinative in outsourcing decisions nor are they so trivial as to be inconsequential.

Understanding these features is important because even though our propositions are strongly corroborated in patent work, we need to appreciate the extent to which they can be generalized to other types of knowledge-based work. For example, can a virtuous cycle of supplier expertise development take hold in biomedical contract research services, which is both interdisciplinary and large-team oriented? What is the influence of (relatively shallow) domain knowledge on the outsourcing of software development services for online bill payment systems? What are the prospects for supplier firms in providing product design services, which may be viewed as an important strategic area by client firms? These potential limitations to our theoretical arguments in other settings has implications not only for outsourcing decisions, but also for how firm and industry boundaries are reinforced (or not) and evolve over time. An exploration of these boundary conditions can also contribute towards a clearer understanding of how different types of knowledge contribute towards firm capabilities.

Some potential insight into the limits (and moderators) of our theory is provided by a deeper investigation of our results among “the industries” in our sample. While we controlled for five technology groups in our reported analyses, we also re-ran our models on the five technology group sub-samples separately (with firm-quarter fixed effects) and compared our main effects. In our (unreported) results, we found that H1 (outsourcing of consequential activities) is supported in three of the five technology groupings—all except chemicals and drugs & medical. This may be because patents play a key role in rent appropriation in these technologies (Cohen et al. 2001) so that patents related to prior litigation may not be viewed very differently from other patents in terms of how consequential they are to the firm. In other words, patenting may be viewed as being important for competitive advantage in these technologies, and not an ancillary activity.

Further, we found that H2 and H3 are supported in all five technology groups; however the estimated effects of firm domain and context-specific knowledge on outsourcing are much

stronger in chemicals and drugs & medical, particularly in the latter. Interestingly, the overall levels of outsourcing in these two technology groups are also low. These findings are consistent with the notion that the scientific domain knowledge needed in pharmaceuticals (and chemicals) may be quite specialized and deep, as opposed to generic and broad, and there may also be a significant complement of deep context-specific knowledge in these industries. Naturally, there are higher communication and coordination barriers for suppliers to absorb this specialized knowledge and effectively service client firm needs. Consistent with our findings about interactions between different types of knowledge, the specialized and deep nature of domain (and context-specific) knowledge in these technologies may also give internal suppliers an advantage in performing knowledge work despite their weaker professional expertise. Overall, our findings across technology groups suggest that the strategic importance of the knowledge-based activity and the extent to which domain (and context-specific) knowledge is deep and specialized are important moderators in the generalizability of our main propositions. However, these and other factors need to be explored in a more systematic manner in future work.

Another limitation of our study is that it focuses on large *Fortune* 500 firms, but small and large organizations represent different organizational forms, which may face different resource constraints. For example, smaller firms may have more difficulty developing internal knowledge capabilities due to limited scale or financial resources, and as a result may need to rely more on external suppliers for knowledge-based activities. Furthermore, compared to large firms, small firms may face different competitive pressures and may therefore be motivated by different goals. Thus, future research can extend this study by examining the extent to which our findings apply to small- and mid-size firms. Finally, in this study we examined a specific type of knowledge-based activity, the filing of patents. However, despite the robustness of our results within the patent setting, we encourage future researchers to test our model in the context of other knowledge

settings – such as financial services, accounting services, and information technology services – in order to establish the generalizability of our theory across industries.

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Table 1: Descriptive Statistics of Key Variables

Variables	Measures	Not Outsourced			Outsourced		
		Mean	Std. Dev.	Within Std. Dev.	Mean	Std. Dev.	Within Std. Dev.
Consequential Activity (H1)	Dummy=1, if patent cites a litigated patent	0.126	0.332	0.320	0.151	0.358	0.337
Firm Domain Knowledge (H2)	(Log) No. internalized patents in same class	2.801	1.819	1.584	2.077	1.853	1.293
Firm Context-Specific Knowledge (H3)	(Log) No. of own cited patents internalized	0.538	0.643	0.612	0.296	0.519	0.446
Forward Citations	(Log) No. of citations to focal patent (est.)	2.185	1.122	1.034	2.414	1.105	0.980
Prior Outsourcing in Knowledge Domain	(Log) No. outsourced patents in same class	0.918	1.281	0.927	1.938	1.637	1.250
Prior Related Outsourcing	(Log) No. of own cited patents outsourced	0.049	0.208	0.192	0.227	0.437	0.403
No. of Patent Claims	(Log) No. of claims in focal patent	1.786	0.985	0.952	1.691	0.899	0.846
Foreign Inventor	Dummy=1, if first inventor is outside U.S.	0.091	0.287	0.274	0.063	0.243	0.212
Drugs & Medical	Technology Group Dummy Variable	0.125	0.330	0.231	0.066	0.248	0.153
Chemicals	Technology Group Dummy Variable	0.212	0.408	0.362	0.120	0.325	0.263
Electrical & Electronics	Technology Group Dummy Variable	0.273	0.445	0.399	0.294	0.456	0.404
Computers & Communications	Technology Group Dummy Variable	0.211	0.408	0.331	0.350	0.477	0.378
Other Technologies	Technology Group Dummy Variable	0.023	0.149	0.143	0.016	0.127	0.112
Number of Observations		43301			16289		
Number of (Firm-Qtr) Groups		1242			1242		

Table 2: Correlations Between Variables

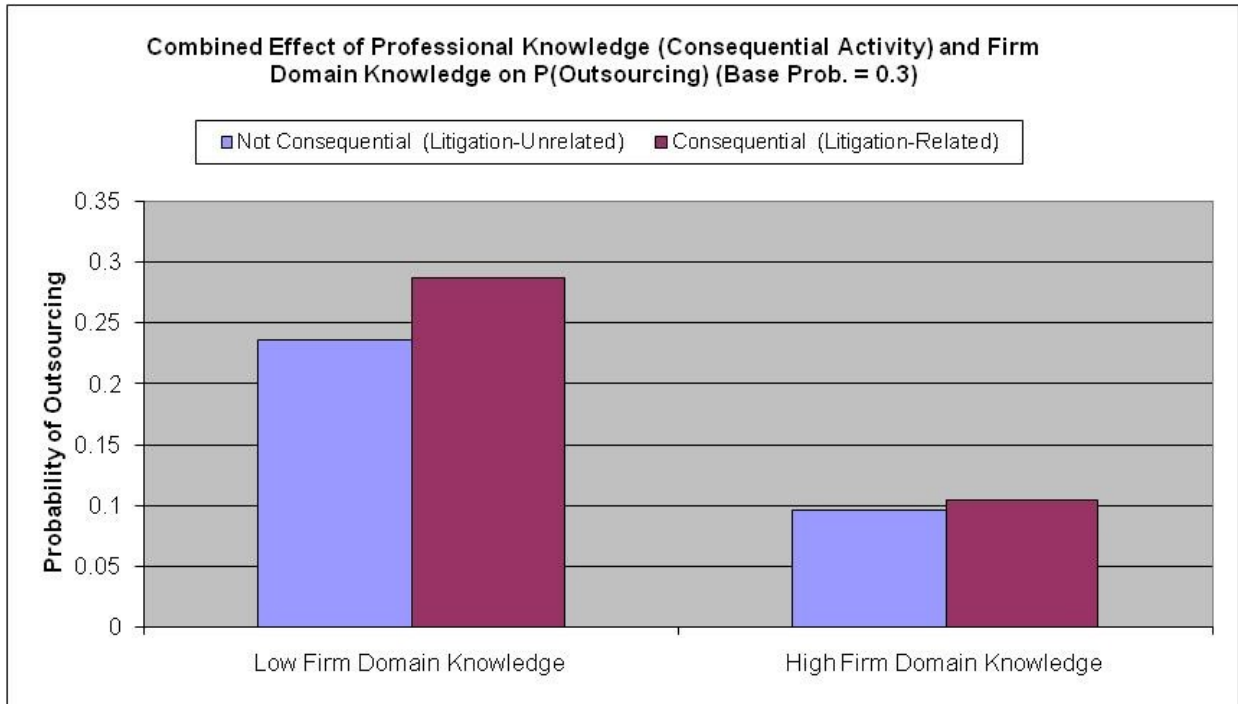
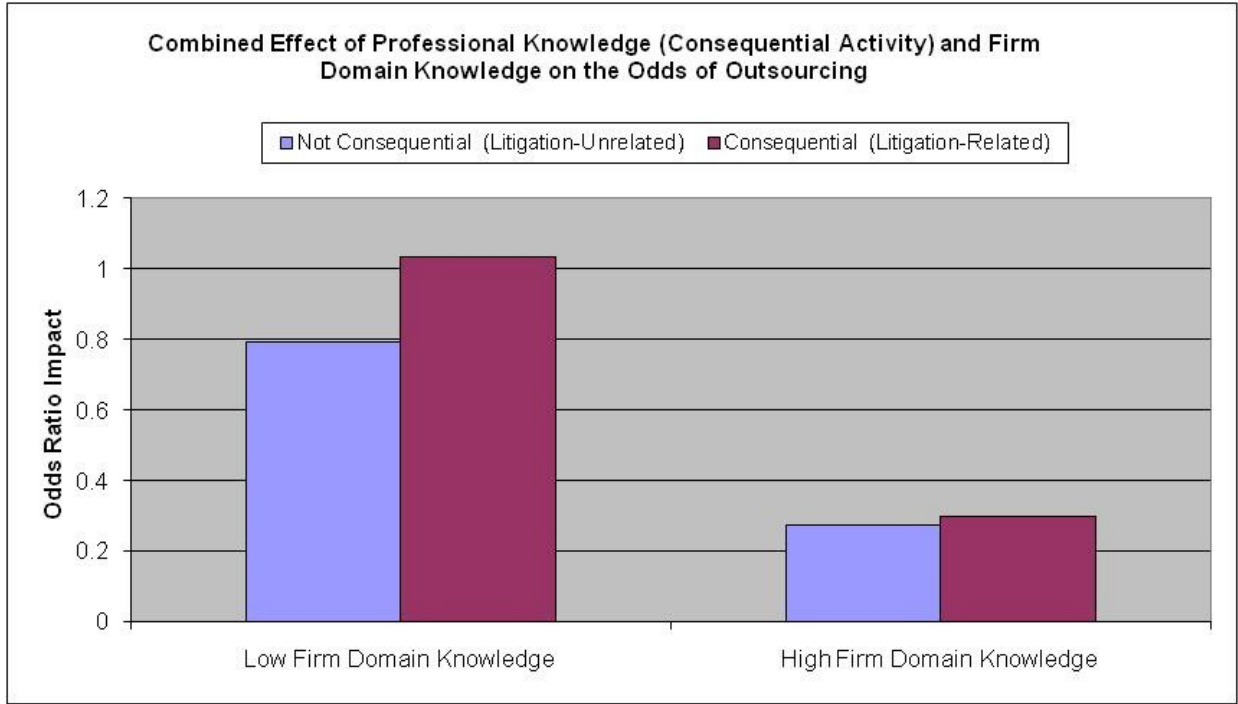
Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Consequential Activity	1.00												
2 Firm Domain Knowledge	-0.01	1.00											
3 Firm Context-Specific Knowledge	0.02	0.29	1.00										
4 Forward Citations	0.09	0.10	0.06	1.00									
5 Prior Outsourcing in Knowledge Domain	0.03	0.49	0.04	0.20	1.00								
6 Prior Related Outsourcing	0.06	0.00	0.02	0.11	0.32	1.00							
7 No. of Patent Claims	0.02	-0.07	0.02	0.05	-0.11	-0.02	1.00						
8 Foreign Inventor	-0.01	0.05	-0.05	-0.05	0.02	-0.03	-0.01	1.00					
9 Drugs & Medical	0.10	0.08	-0.01	-0.06	-0.07	-0.06	0.14	0.05	1.00				
10 Chemicals	-0.03	-0.14	0.05	-0.18	-0.18	-0.06	0.03	0.02	-0.17	1.00			
11 Electrical & Electronics	-0.08	0.07	-0.04	0.03	0.01	-0.01	-0.08	-0.03	-0.22	-0.30	1.00		
12 Computers & Communications	0.06	0.16	-0.01	0.24	0.34	0.12	-0.09	0.00	-0.20	-0.28	-0.36	1.00	
13 Other Technologies	0.00	-0.04	0.01	-0.04	-0.09	-0.03	0.03	-0.01	-0.06	-0.08	-0.10	-0.09	1.00

Table 3: (Firm-Quarter) Fixed Effects Logit Models for the Outsourcing of Patent Legal Work

	Dependent Variable = Probability of Outsourcing					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Consequential Activity		1.183** (0.042)			1.163** (0.042)	1.305** (0.078)
Firm Domain Knowledge			0.696** (0.008)		0.720** (0.009)	0.715** (0.010)
Firm Context-Specific Knowledge				0.651** (0.014)	0.726** (0.017)	0.654** (0.029)
Consequential * Domain Knowledge						0.955* (0.018)
Consequential * Context-Specific Knowledge						1.006 (0.060)
Domain Knowledge * Context-Specific						1.034** (0.012)
Forward Citations	0.985 (0.011)	0.981+ (0.011)	0.985 (0.012)	0.998 (0.012)	0.991 (0.012)	0.990 (0.012)
Prior Outsourcing in Knowledge Domain	1.090** (0.012)	1.091** (0.012)	1.540** (0.024)	1.114** (0.012)	1.517** (0.024)	1.512** (0.024)
Prior Related Outsourcing	2.494** (0.097)	2.483** (0.096)	2.230** (0.087)	2.682** (0.105)	2.371** (0.094)	2.368** (0.094)
No. of Patent Claims	0.951** (0.013)	0.951** (0.013)	0.942** (0.013)	0.954** (0.013)	0.946** (0.013)	0.947** (0.013)
Foreign Inventor	0.742** (0.033)	0.746** (0.033)	0.750** (0.034)	0.701** (0.032)	0.721** (0.033)	0.722** (0.033)
Drugs & Medical	1.104 (0.071)	1.092 (0.070)	1.349** (0.087)	1.084 (0.070)	1.297** (0.084)	1.299** (0.084)
Chemicals	0.773** (0.035)	0.772** (0.035)	0.790** (0.036)	0.781** (0.035)	0.795** (0.036)	0.794** (0.036)
Electrical & Electronics	0.999 (0.040)	0.999 (0.040)	1.123** (0.045)	0.984 (0.040)	1.100* (0.045)	1.098* (0.044)
Computers & Communications	0.839** (0.038)	0.829** (0.038)	0.967 (0.044)	0.860** (0.039)	0.962 (0.044)	0.960 (0.044)
Other Technologies	0.776** (0.068)	0.772** (0.068)	0.828* (0.074)	0.777** (0.069)	0.820* (0.073)	0.814* (0.073)
Number of Observations	59590	59590	59590	59590	59590	59590
Number of (Firm-Qtr) Groups	1242	1242	1242	1242	1242	1242
Log Likelihood	-20896.1	-20884.8	-20432.2	-20701.1	-20322.1	-20314.9

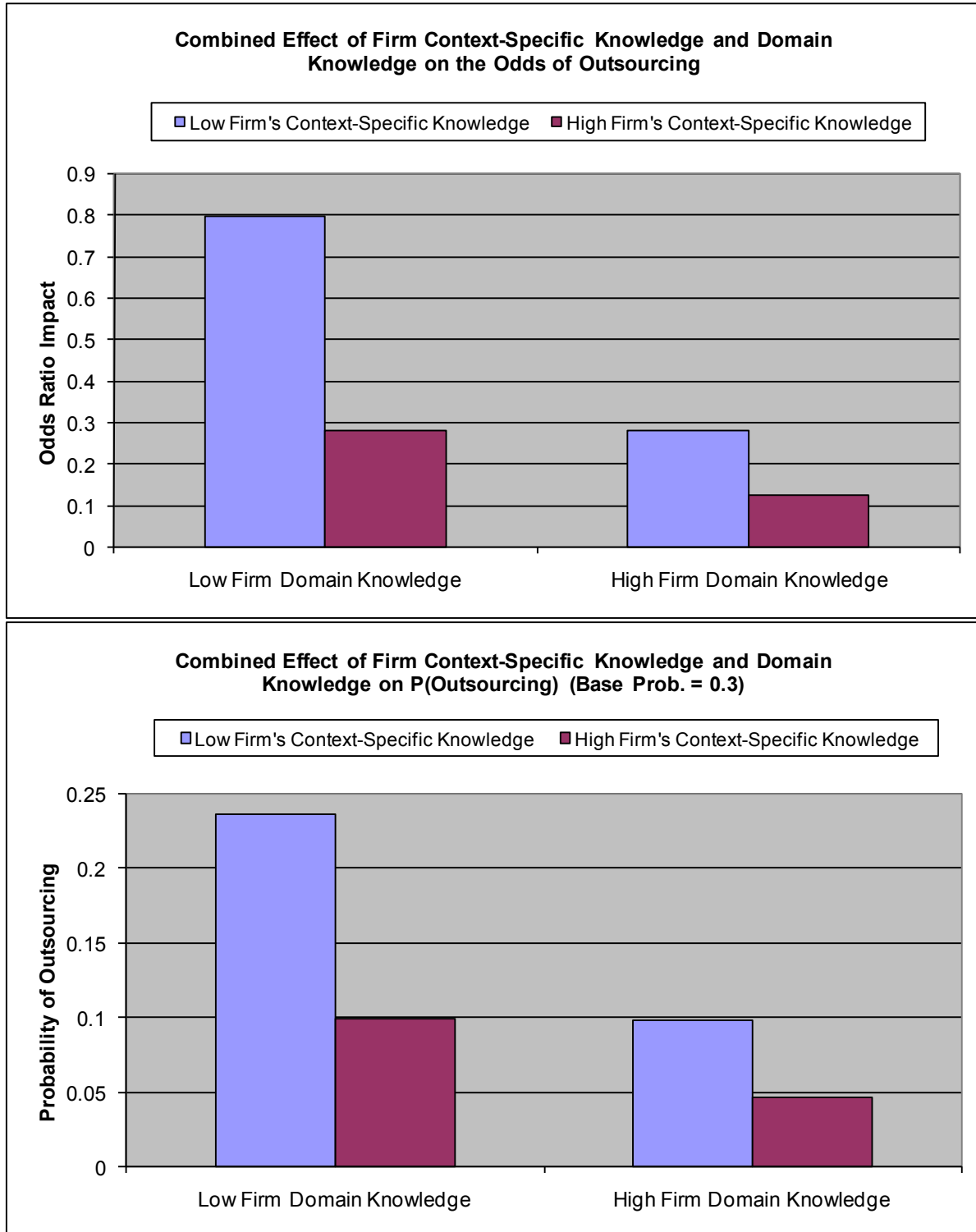
Standard errors in parentheses (Significance Levels: + = 10%; * = 5%; ** = 1%)
 Estimates reported are exponentiated coefficients (odds ratios)

Figure 1: Magnitudes of the Joint Effect of Professional Knowledge (Consequential Activity) and Firm Domain Knowledge



Choice of Low and High Values of Variables: Since *Consequential Activity* is measured with a dummy variable, we simply use “0” and “1” for the low and high values, respectively. For *Firm Domain Knowledge*, we use the 25th and 75th percentiles of the variable as the low and high values, respectively.

Figure 2: Magnitudes of the Joint Effect of Firm Domain Knowledge and Context-Specific Knowledge on Outsourcing



Choice of Low and High Values of Variables: For *Firm Domain Knowledge* as well as *Firm Context-Specific Knowledge*, we use the 25th and 75th percentiles of the variables as the low and high values, respectively.