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ORGANIZATIONAL KNOWLEDGE AND INNOVATION IN BUSINESS SERVICES[1]

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ABSTRACT

This study builds a typology of organizational knowledge in business services and empirically examines the effects of knowledge on innovation performance. We suggest that firms differ with respect to their knowledge creation approaches and that these approaches have implications for firm performance in terms of innovation success. A conceptual framework of knowledge assets with degrees of tacitness and collectiveness as the principal axes is used to ground the empirical analysis. We find that innovation in business services is associated with both tacit and explicit collective knowledge, and with explicit individual knowledge. In contrast, relying solely on tacit knowledge held by individuals may hamper innovation. These empirical results shed new light on the debates in organization studies concerning the strategic effects of tacitness and collectiveness of knowledge: Innovation benefits may be gained from codifying knowledge and making it appropriable at the collective level, as opposed to the individual one. Additionally, our results indicate that tacit collective knowledge is more closely associated with new service introductions while explicit collective knowledge is associated with service improvements. In other words, tacit collective knowledge may be conducive to significant departures from existing capabilities and activities while explicit collective knowledge is conducive to incremental improvements. The firm's knowledge creation approaches thus need to be aligned with its service strategy.

Key words: Organizational knowledge, innovation, business services, supply relationships

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1 Introduction

The growing literature on the knowledge-based view of the firm argues that firms' practices toward the generation of knowledge can have substantial effects on their performance (Wernerfelt 1984; Dierickx and Cool 1989; Conner 1991; Teece, Pisano, and Shuen 1997, among others). Other scholars suggest that knowledge creation is insufficient, that successful organizations also are characterized by extensive knowledge sharing and integration (Clark and Fujimoto 1991; Iansiti and Clark 1994; Okhuysen and Eisenhardt 2002). Sharing of best practices alleviates inefficient redundancy in learning and innovation (Szulanski 1996). Knowledge integration is necessary for exploiting complementarities among knowledge assets (e.g., Henderson and Cockburn 1996), as well as for achieving coordination (Grant 1996). However, to generate sustainable competitive advantage, these knowledge-based activities and resources must be heterogeneous and difficult to replicate or transfer across firms, and not generally available through the markets (Henderson and Cockburn 1994). Innovation—generation of novel combinations from existing knowledge—is a key process that underlies the creation of these kinds of unique capabilities to support sustainable advantage. Knowledge integration that enables innovation is thus strategically of utmost importance for firms, but the actual practices to achieve it are not well understood. These are the topic of this empirical study.

Extant literature on organizational knowledge emphasizes the distinction between tacit and codified forms of knowledge (Nelson and Winter 1982; Nonaka 1994; also Levitt and March 1988 although they use different terms). Codified knowledge is easier to exploit in an organization because of its transferability, but therein also lies a danger of leakage. Tacit knowledge may be easier to appropriate and thus it may provide more sustainable competetitive advantage (Winter 1987; Spender 1996). However, existing studies have not thoroughly examined the conditions under which each type of knowledge is advantageous. Here we focus on the implications for innovation. Nonaka's (1994) theory of knowledge creation provides a conceptual startingpoint to examine these issues with empirical data.

Knowledge can be held by individuals in an organization, or it can be jointly possessed by groups within the organization. "Ownership" of knowledge is important because it determines who can access and use knowledge in an organization: if a competence is embodied in an individual, the organization cannot appropriate or use it without the cooperation of the individual. In contrast, if knowledge is held collectively, in other words, it is either shared or distributed in the sense that it is valuable only in a specific organizational context, the firm is less vulnerable to departures of key people or other internal negotiations. While control of assets has not been a central aspect in the knowledge-based theory of the firm, we argue here that whether knowledge is controlled in an organization by individuals or by groups is highly relevant for knowledge creation outcomes, and, as a result, innovation, because locus and control of knowledge affect the potential for its integration.

Empirical studies in the knowledge-based view of the firm have largely concentrated on industrial R&D environments (e.g., Eisenhardt and Tabrizi 1995; Hansen 2002; Henderson and Cockburn 1994; Zander and Kogut 1995). The empirical context of knowledge-intensive business services thus differs from previous work. As in earlier studies, we are interested in the effects on innovation, but the novelty of this study is to demonstrate a link between a firm's general knowledge management practices and its innovation performance. We argue that the way knowledge is organized and mobilized, not only in R&D but in the whole organization, has implications for the productivity and effectiveness of innovation.

This study examines the strategic implications of knowledge management activities in business services such as engineering, R&D, and management consulting services. The firm performance measure used here is innovation output. In one sense, innovation itself is one of the key knowledge creation activities. One can also argue, however, that successful new service introductions are evidence of dynamic performance that is likely to be associated with firm growth and profitability (Geroski, Machin, and Reenen 1993). Successful innovations can thus be viewed as a firm performance indicator. In the conventional view, the main innovation inputs include R&D investments, while this paper focuses on the impact of more novel measures of knowledge-based assets and activities. The goal is to assess how types of knowledge and their location in the organization influence performance in new service development. The empirical test is based on a unique survey dataset of 167 business service firms. Results suggest that it matters for innovation performance who in the firm possesses knowledge, individuals or groups, and whether it is predominantly in a tacit or codified form.

2 Management of Knowledge in Professional Services: Literature and Empirical Hypotheses

Knowledge is an elusive asset to manage. Perhaps paradoxically, knowledge can be both difficult to appropriate and to transfer (Teece 1977; 1986; Winter 1987). Thus, depending on the situation, involuntary transfers (spillovers) or stickiness can complicate knowledge management strategies. Pioneering work identified the distinction between tacit and explicit knowledge as the key to understanding spillovers and stickiness (e.g., Polanyi 1966; Nelson and Winter 1982). In discussing the organizational implications of knowledge, Kogut and Zander (1992, 1996) argued that firms are better than markets in sharing and transferring knowledge of individuals and groups. Firms are social organizations where the creation of joint identity and culture take place and facilitate communication of tacit knowledge. Codifiable and teachable knowledge, in contrast, can also be transmitted across organizational boundaries (Kogut and Zander 1993). Indeed, in another paper these authors find that the degrees of codifiability and teachability significantly influence the speed of knowledge transfer (Zander and Kogut 1995).

Recent work on knowledge in organizations emphasizes the process of "knowing" as a complementary view to understanding the strategic importance of knowledge. In this perspective, socially situated practice supports the "enactment" of knowledge in an organization (Lave and Wenger 1991; Brown and Duguid 1998; Orlikowski 2002). Here, the nature of knowledge in terms of tacitness or explicitness remains central to understanding what kinds of practices can be adopted, but the ongoing organizational or individual practices to use knowledge are what potentially bring about the implications for firm performance. Given this view, tacit knowledge is a latent asset unless it is constantly and systematically enacted (Orlikowski 2002.; Daft and Weick 1984).

Because firms' knowledge is partially tacit, certain skills are tightly embedded in individuals and can be separated only by incurring a substantial cost, which in many cases is prohibitively high. Nevertheless, explicit (codified) knowledge can sometimes be generated from tacit knowledge (Winter 1987; Cowan 2001; Prencipe and Tell 2001). Obviously, the degree of tacitness increases the costs of knowledge transfer and improves the potential for appropriability of knowledge assets—sticky assets are less likely to leak to competitors (Spender 1996).

An ongoing debate concerns the extent to which tacit and explicit are meaningfully separable aspects of knowledge. For example, Cook and Brown (1999: 382) argue that each form of knowledge has a distinct functionality. Orlikowski (2002), on the contrary, submits that tacit and explicit skills are intertwined to a degree that makes it useless to attempt to analyze them separately. Instead, she advocates focusing on practice, as explained above, where both aspects of knowledge are used inseparably. Our position is aligned with Cook and Brown in arguing that explicit knowledge exists, although it only becomes valuable through enaction that combines it with tacit knowhow. However, practices based on combinations of tacit and explicit knowledge can be distinguished from practices based solely on tacit knowledge. Therefore, tacit knowing can be identified as a distinct form of knowing. Nevertheless, the perspective that emphasizes knowing provides a useful and complementary approach to understanding and measuring knowledge in organizations. When knowledge is understood not only as a static asset but as ongoing practices to apply and improve those assets, new opportunities for its measurement arise.

The second important characteristic of knowledge from the viewpoint of this study is that firms' productive knowledge has an organizational dimension. Many authors have discussed the related notions of organizational, collective, distributed, architectural, or social knowledge (Hayek 1948; Nelson and Winter 1982; Spender 1996; Henderson and Clark 1990; Henderson and Cockburn 1994). If there exist complementarities among individuals or organizational units that possess relevant competencies, then these component skills are more valuable when integrated. Division of labor among organizational units can thus create learning efficiencies because of ensuing specialization in accumulating different kinds of complementary knowledge. The management challenge is to enable sharing and integration—combination—of knowledge by establishing organizational linkages and communication channels between the complementary units or individuals (e.g., Kogut and Zander 1992, 1996). The degree of collectiveness of knowledge, therefore, is at least partially a managerial decision. For example, if employees work and learn in teams, they likely will develop collectively controlled and utilized skills. In contrast, if employees' incentives and responsibilities are based solely on individual actions, their learning will likely result in individually controlled skills.

Thus far the relative importance of different types of knowledge for firm performance has been insufficiently investigated in the knowledge-based view of the firm. Among the few who have addressed this issue, Spender (1996) argues that tacit and collectively held knowledge is most likely to yield sustainable strategic advantage, because this type of knowledge is difficult to imitate and even communicate, and cannot be appropriated by individuals. On the other hand, Nonaka (1994; Nonaka and Takeuchi 1995) emphasizes the conversion of knowledge, particularly from tacit to explicit. Here, codification is requisite for combination that leads to innovation. Despite these useful characterizations of knowledge and learning processes, we know little about the balance between tacit and explicit knowledge; neither do we understand on what factors it depends. In short, should firms develop all kinds of knowledge in a balanced fashion, or are some types of knowledge more valuable than others in certain situations?

We submit that to analyze firms' capabilities, the fundamental dimensions are indeed tacitness and collectiveness. Tacitness determines the transferability of knowledge, while collectiveness determines who in the organization can access and use knowledge. Transferability and access to knowledge have strategic implications for how knowledge can be used in the organization. Figure 1 identifies the different types of knowledge building on Cook and Brown (1999) and Spender (1996). Empirical operationalization of these concepts is discussed in section 3.

Figure 1 Dimensions of organizational knowledge in knowledge-intensive business services

	Individual	**Organizational**
Tacit	Expertise, skills "*Automatic knowledge*"	Joint routines, processes "*Collective knowledge*"
Explicit	Education, professional knowledge "*Conscious knowledge*"	Intellectual property, products, services "*Objectified knowledge*"

For business service firms, individual experts' tacit and explicit skills are extremely valuable resources because such businesses basically advise client organizations in highly specialized fields of professional knowledge. Individual consultants obtain skills through both education, professional training, and learning on the job. Some tacit skills in design and technical or artistic problem solving may also be based on innate talent. Here we distinguish tacit expertise from explicit professional knowledge acquired largely through formal education.

While many knowledge-based business service firms operate on the basis of their skilled individual employees, some of these firms have found ways to aggregate skills onto the organizational level beyond individuals. First, employees can be organized into teams where specialists of different competence areas provide complementary skills. Second, firms may codify procedures and service solutions into well-defined packages or technologies (Creplet et al. 2001). These practices render originally individual-based knowledge organizationally controlled (cf. Hansen, Nohria, and Tierney 1999; Löwendahl 1997).

In principle, codified solutions, concepts, and technologies can be "owned" (appropriated) by the organization, even if enforcement of these property rights is difficult. In the case of complementary tacit competencies in a team, opportunities for the firm to expropriate the competencies are limited, but appropriability is low also for the employees: Due to complementarities, an employee's competencies are less valuable outside of the team, which reduces the incentives for leaving. In contrast, firms have fewer mechanisms to control the use of individuals' independently applicable skills, despite no-compete, inventions, and secrecy clauses that are now routinely stipulated in employment contracts of highly skilled experts.

Indeed, internal control of knowledge resources is an aspect of knowledge management that has not been thoroughly analyzed in extant literature. Löwendahl's study (1997) on the issues of control by individuals and groups in professional service firms is a useful start. We build on her work and submit that internal control of knowledge assets, in addition to external control in terms of appropriability (Teece 1986), is an important factor to determine who profits from learning and innovation. Appropriation of rents from knowledge assets affects incentives to invest in knowledge creation.

Along the lines of Cook and Brown (1999), one can argue that the four types of knowledge in figure 1 are present in any activity or any service firm. We suggest, however, that firms may emphasize different elements of this framework. For instance, many startup consultancies operate in the individual knowledge mode, and only over time may they choose to develop organization-level assets and practices. Developing organizational assets is costly, because it necessitates investments in either codification to generate explicit intellectual property or communication and linkages to facilitate creation of team routines. Hence, under uncertainty about the returns, some firms may choose not to incur these costs and thus continue to rely on individuals' knowledge.

Integration of intellectual assets in order to generate collective knowledge refers to the process of combining potentially complementary components of knowledge that reside in different and possibly distant parts of the organization (Prahalad and Hamel 1990). Without (costly) integration, organizational units will carry on their activities independently, and the firm will miss opportunities for "synergy." A similar argument is presented in the innovation literature, where innovation is seen as a process of making new combinations (Schumpeter 1934; 1942). Studies of innovation processes also suggest that integration of internal activities that contribute to new product development is critical for successful innovations (Kline and Rosenberg 1986; Rothwell

1992). Other studies emphasize the need to tap into external, and complementary, sources of information (Cohen and Levinthal 1990; Levin, Cohen, and Mowery 1985; Henderson and Cockburn 1994). More recently, Fleming (2001) explored the concept of combinatory innovation by analyzing patent citations as evidence of combinations of existing technologies. The extant view on innovation thus suggests that integration of existing knowledge components is crucial for the generation of new products and technologies.

The notion of innovation as new combinations is illustrated in an empirical study by Ebadi and Utterback (1984), who found that diversity of communication sources correlates positively with technological innovation. Similarly, Fleming and Sorensen (2001: 1035) argued based on their empirical results that if inventors "only refine existing solutions, they will rarely enjoy breakthrough success. To maximize the likelihood of useful inventions, researchers should work with a large number of components."

Building on the literatures on knowledge and innovation, we propose that individually controlled resources are associated with local and tacit learning by individual experts that is not conducive to major innovations. Moreover, when knowledge resources are controlled by individual experts, the organization has weaker incentives to invest in R&D activities, because new knowledge strengthens experts' bargaining power, thus making the benefits of R&D likely to accrue to individual employees through increases in compensation. In contrast, when key resources are collectively utilized, the organization is better positioned to support knowledge sharing through socialization and combination (Nonaka 1994), both within the firm and across firm boundaries, which may lead to more radical new ideas. Thus, business service firms' strategic orientation to collective resource control is expected to correlate with their innovation performance:

H1: Emphasis on collective practices toward knowledge generation and mobilization is more conducive to innovation than emphasis on individually based practices.

The distinction between the effects of tacit and explicit knowledge on innovation has not been thoroughly empirically analyzed in the literature. In a well-known case study of the development of the bread machine, Nonaka and Takeuchi's (1995) explain how, in the process of codifying the tacit skill of kneading into a motion that can be replicated by a machine, concepts were developed through trial and error, and eventually the bread-making practice was thus "disembedded" from the master baker. This view suggests that radical innovations require some degree of codification of underlying tacit knowledge components to enable combination. The flipside is that tacit knowledge is likely to lead to incremental learning and improvement.

On the contrary, Senker (1995), building on Rosenberg (1982), argues that innovation at the forefront of scientific and technological development depends to a significant degree on tacit knowledge. When new combinations are created, they emerge first as tacit "hunches" and intuitions based on research practice before explicit concepts and solutions can be developed. In this view, innovation takes place through application of tacit problem-solving and creativity. An implication is that radical innovations require strong tacit knowledge creation processes. Then the emphasis on explicit knowledge may be conducive to incremental innovations, not to technological breakthroughs.

These two opposing predictions can be empirically assessed using the current dataset. We have information about both tacit and explicit knowledge creation practices in the business service firms and can thus test which demonstrate a stronger statistical relationship with two different innovation measures: incremental improvements and introductions of completely new kinds of services that represent more radical innovations. Hypotheses 2a and 2b articulate the view that explicit collective knowledge is associated with new service introduction, whereas tacit collective knowledge is associated with incremental service improvements. Hypotheses 3a and 3b express an opposite view of the roles of these two types of collective knowledge in service innovation.

H2a: Explicit collective knowledge is associated with new service introductions more strongly than is tacit collective knowledge.

H2b: Tacit collective knowledge is associated with incremental service improvements more strongly than is explicit collective knowledge.

H3a: Tacit collective knowledge is associated with new service introductions more strongly than is explicit collective knowledge.

H3b: Explicit collective knowledge is associated with incremental service improvements more strongly than is tacit collective knowledge.

3 Descriptive Analysis of the Dataset: Service Strategies and Client Relationships of Knowledge-Intensive Business Service Firms

This section explores empirically how characteristics of knowledge and practices related to the use and creation of knowledge in a business service organization affect innovation performance. Innovation in service industries remains relatively understudied. A few scholars have started to investigate the processes of innovation (Sundbo 1997) and broader innovation patterns in service industries (Evangelista 2000). Earlier studies argue that service industries are qualitatively different from manufacturing industries with respect to their development activities (Barras 1986; Miles 1994; Hauknes 1998) but Evangelista's work (ibid.) suggests that investments and activities related to service innovation are generally not all that different from manufacturing innovation. Variation *within* the two broad sectors is larger than that *across* sectors. To our knowledge, however, innovation in business services has not been analyzed with cross-sectional survey data, even though business services represent an interesting empirical field because of the rapidly growing importance of these industries as producers and distributors of knowledge in the economy (Tomlinson 2000).

This section describes the dataset and the constructs to be used in the empirical analysis. The data were collected through a mail survey of Finnish business services, administered by the Research Institute of the Finnish Economy. A questionnaire, developed in cooperation with Statistics Finland, was mailed to 445 firms, 46 of which resulted in invalid responses.[2] Questionnaire recipients were identified from the lists obtained from Statistics Finland of the 100 largest firms in each of the six 5-digit NACE industrial classes studied.[3] Focusing on the largest firms was necessary because of the small average size of firms in these industries and the emphasis on organizational practices in this study. The CEO was the recipient of the questionnaire, although in some 10% of the cases the CEO delegated responding to other managers. The industries studied include industrial design, advertising, machine and process engineering, electrical engineering, management consulting, and R&D services.

The questionnaire was designed to collect information about the organization of the customer relationships of service firms, their internal incentive systems, and their investments in knowledge creation. The dataset is unusually detailed regarding organizational practices of knowledge management and creation. The response rate was 42%. Based on the information obtained from Statistics Finland, firms responding to the survey were 20% larger than the mean in the target group. Hence, there may exist a large firm bias in the dataset. However, in terms of sales

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[2] E.g., firms that do not operate in the targeted industries, have merged, or have gone out of business. Service subsidiaries of manufacturing corporations were also excluded.

[3] NACE (Nomenclature Générale des Activités Economiques dans les Communautés Européennes) is the industrial classification system used in the European Union, developed by the Eurostat. The levels of classification closely correspond to the North American SIC/NAICS system. Industrial design firms were identified from NACE 74841 (graphical design) where they form a subgroup.

per employee, a rough measure of profitability, the sample firms actually performed slightly worse than the targeted group. There are thus no signs of the "successful firm" bias. Other structural data for these industries are not currently available for the whole dataset. A more detailed selection bias analysis can be carried out for the technical services, i.e., engineering and R&D services, by comparing the current dataset against the technical service industries in the Community Innovation Survey by Statistics Finland (SF 1998). This analysis suggests the possible size and innovativeness biases are not significant (see the appendix).

Table 1 presents basic descriptive indicators along with the measures for innovation output. Innovation indicators come from two survey questions asking, first, whether the firm has introduced completely new kinds of services in the markets in the previous three years (services new to the firm itself, not necessarily to the markets), and second, whether it has introduced significantly improved services in the markets in the same time period. Both questions have binary scales. Also, firms were asked about the share of sales revenue derived from completely new services. This measures the commercial relevance of innovative output from the firm's perspective.

While these questions are likely to be incomplete measures of innovation output, they parallel those used in European Community Innovation Surveys designed by the Eurostat. About half of the firms surveyed here had launched innovative or improved services, more firms making incremental than substantial innovations, as one would expect. These data on new or significantly improved services are used as dependent variables in section 4.

Service development activities (table 1) by KIBS firms are perhaps surprisingly common and entail quite significant investments. Excluding firms for which development investments currently exceed sales (which arguably are in a temporary state and thus do not well represent the sector), 54% of firms report having invested in service development and 20% have a permanent development team or department. On average the firms in the sample invest 3.3% of sales in service development, although the median is only 0.8%. The distribution of R&D investments is thus rather skewed, which also is the case within manufacturing industries.

Table 1 Descriptive statistics

	Mean	Std. deviation	Minimum	Maximum	Cases
Sales (million Finnish markka 1999)	26.2	73.9707	0.1	835	155
Employees (1999)	41	82	1	590	163
Exports per sales (1999)	0.12	0.26	0	1	168
Business group (binary)	0.38	0.49	0	1	165
New service introductions (binary)	0.45	0.50	0	1	166
Service improvements (binary)	0.54	0.50	0	1	163
Share of sales from innovative services (%)	5.8	13.8	0	100	161
R&D investments > 0 (binary)	0.54	0.50	0	1	168
R&D department or team (binary)	0.20	0.40	0	1	162
R&D investments/sales (%)	3.3	9.6	0	100	161
Response rate (%)	42				
Observations	167				

n.a. = not available.
Business group refers to organization structures where service firms surveyed are subsidiaries within larger service corporations. This may have substantial effects on their knowledge creation activities, for which reason it is important to control for this characteristic. E.g., in advertising or management consulting, local firms are registered in the Finnish business registry but may be wholly or partly owned by multinational parents such as McCann-Erickson WorldGroup or Ernst & Young. In this case, they are indicated to be part of a business group. Firms that are not in a business group are thus independent companies.

The main explanatory variables of interest characterize service firms' knowledge resources and control. To empirically operationalize the different types of knowledge identified in figure 1, we combine measures of service modes, education, and self-reported sources of competitive strength. Whether a service firm predominantly supplies "experts for hire" (expert services) or provides predefined service solutions is a key dimension characterizing the firm's service strategy (Löwendahl 1997). These characteristics are argued to correlate with the type of underlying knowledge: Supplying skilled individual experts is assumed to be associated with the application of individual tacit knowledge, while supplying service solutions is assumed to reflect collective explicit knowledge. Survey questions asked respondents to indicate on a scale of 0–3 “how often” they provide expert services and predefined service solutions: never, sometimes, often, or always. An alternative measure for collective explicit knowledge is the binary variable technology licensing, which indicates that the firm licenses technology or service concepts to other firms. This is assumed to reflect the firm’s capability to codify ideas into tradeable and explicit solutions or technologies that can be separated from the organization. However, since this variable may be endogenous with respect to the dependent variables that describe innovation output, it is used as a secondary indicator.

A proxy for collective tacit knowledge is obtained from the survey question asking respondents to assess the sources of their competitive advantage on a scale of 0–3. Of particular interest here is the importance assigned to team-based knowledge. It is assumed that if a firm responds that knowledge residing in teams, as opposed to individuals’ skills, training, and formal education, is an important or a very important source of competitive advantage, then the firm relies on knowledge resources that are tacit and collectively controlled. Competencies of team members are likely to be complementary and thus the value of each is higher in the presence of others. Moreover, team-based knowledge and supporting routines evolve from practice and participation and are usually not codified into formal procedures. This type of knowledge is thus largely tacit. However, the team knowledge variable is based on managers’ very subjective perceptions. This is a weakness of our measure.

Finally, explicit and individually controlled knowledge is captured here with a measure of higher education attainment in the firm, defined as the share of employees with university degrees or higher. We assume that skills obtained through professional education are largely articulable, although in some design-based business areas this may not be the case. In any case, the theories and factual knowledge gained in formal schooling are certainly explicit, even if they often need to be combined with tacit insights to be valuable. Indeed, our measure for tacit skills, expert service mode of operation, probably overlaps somewhat with the education variable. However, this does not matter as long as the education measure distinguishes expert services based on explicit knowledge from completely tacit ones.

Table 2 presents basic statistics for the relevant survey questions. Within service projects, more KIBS firms' operate according to the expert service mode than as providers of predefined solutions. Breakdown by industry (reported in the appendix) indicates that this is particularly true of industrial designers. These two modes of operation are more balanced across firms in management consulting. Despite these opposite characteristics, management and design consulting services are also similar in that they are the two industries where individual explicit knowledge in the form of higher education is abundant. As regards technology licensing, R&D services and advertising represent the polar opposites. R&D service providers produce codified technologies almost by definition, and management consulting and engineering industries are also relatively active in the markets for solutions or technologies, whereas advertising is characerized by a more tacit knowledge base. Indeed, knowledge residing in teams, our proxy for collective tacit knowledge, is most relevant as a source of competitive advantage in advertising and less important in industrial design and engineering. Thus there is substantial variation across industries which we account for by controlling for industry differences in the estimations.

Table 2 Service firms' knowledge resources

	Descriptive statistics				Correlations				
	Mean	Standard deviation	Min.	Max.	Higher education	Expert skills	Service solutions	Technology licensing	Team knowledge
Individual explicit: Higher education degrees (share of employees)	0.33	0.31	0	1	1				
Individual tacit: Expert skills	2.1	0.76	0	3	0.13	1			
Organizational explicit: (a) Service solutions	1.3	0.84	0	3	-0.03	0.14	1		
(b) Technology licensing (out)	0.19	0.39	0	1	-0.03	-0.09	0.05	1	
Organizational tacit: Competitiveness based on knowledge in teams	2.2	0.74	0	3	-0.07	0.15*	0.08	0.04	1
R&D intensity R&D investments per sales (%)	2.8	5.9	0	59	0.11	-0.03	-0.02	0.08	0.06

Original survey scales: 0 (not important) – 3 (very important), except for higher education levels (share), technology licensing (0/1 binary variable), and R&D intensity (%). 0—3 scales were reduced to binary scales for the regression analysis in order to avoid an interval scale interpretation of ordinal scales. However, estimation results were qualitatively similar using original scales. * indicates significant correlation at the 5% level.

Moreover, we find that variation across firms is significant. Both standard deviation and the minimum and maximum values indicate that firms operate differently with respect to these measures. Table 2 also provides correlations among the knowledge variables. The low correlations suggest that the variables are independent and thus firms develop differential competence positions. The exception is that the expert strategy may often be deployed in combination with team-based strategies.

In the estimations, ordinal survey variables are used in a transformed binary form to avoid the interpretation of ordinal scales as interval ones. Robustness of the estimation results with respect to using the transformed binary variables was checked and similar results are obtained with the original survey scales as with the binary variables. The transformation is as follows: for the variables service solution and expert skills, if the original response was 2 or 3 on a scale of 0 to 3, the dummy variable obtains a value of 1, otherwise the dummy value is 0. For the team knowledge variable the cutoff point was higher: the dummy obtains the value of 1 when the original variable equals 3. This way we shift the groups defined by the dummy variable closer to an even split of the sample. Correlations among these estimation variables are provided in the appendix.

4 Empirical Analysis

Estimation approach

The empirical model in equation 1 specifies a firm's innovation output as a function of its general and structural characteristics (size, export orientation, business group), service development activities, and knowledge assets and practices. Service development activities include measures for R&D investments and the presence of a permanent R&D team or department.

Equation 1

$$\text{INNOVATION OUTPUT} = f(\alpha + \beta_1 * \text{SIZE} + \beta_2 * \text{EXPORTS} + \beta_3 * \text{GROUP} + \gamma * \text{DEVELOPMENT ACTIVITIES} + \delta * \text{KNOWLEDGE ASSETS} + \eta * \text{INDUSTRY DUMMIES})$$

Firm size correlates positively with the probability of innovation if there are increasing returns to scale in innovation activities. Operating in export markets is expected to provide incentives to create new and innovative services, as in many studies of manufacturing industries. Association with a business group may enable the firm to benefit from knowledge flows from the headquarters' R&D function, for which reason we expected GROUP to have a positive coefficient.

The explanatory variables of interest include the various types of knowledge assets and practices (EXPERT, EDUCATION, TEAM, SOLUTION, and LICENSING) and direct development activities (R&D DEPARTMENT, R&D INTENSITY). The hypotheses specified in section 1 implied, first, that collective control of knowledge, represented by TEAM, SOLUTION, and LICENSING, is expected to support innovation more strongly than is orientation toward individual resource control. Second, we will assess the effects of tacit and explicit collective knowledge on the type of innovation (hypotheses 2 and 3).

Estimation results

First consider the estimation results of the basic model in table 3. The dependent variables are binary indicators for firms that made service improvements or new service introductions and the estimation method is Probit maximum likelihood.

Table 3 Knowledge measures as determinants of service improvements and innovations

Dependent variable:	IMPROVEMENT			NEW SERVICE		
	Coeff.	**Std. error**	**Marginal effects**	**Coeff.**	**Std. error**	**Marginal effects**
Constant	-0.77**	0.39	-0.31**	-0.73*	0.38	-0.28*
EMPLOYEES	0.00	0.00	0.001	0.002	0.002	0.001
GROUP	0.80**	0.26	0.32**	0.34	0.24	0.13
EXPORTS	-0.41	0.46	-0.16	-0.57	0.49	-0.22
R&D DEPARTMENT	0.79**	0.32	0.31**	-0.05	0.30	-0.02
R&D INTENSITY	-0.30	0.38	-0.12	1.41	1.80	0.55
EXPERT	-0.18	0.28	-0.07	-0.64**	0.27	-0.25**
EDUCATION	0.76*	0.45	0.30*	0.94**	0.45	0.37**
TEAM	0.10	0.26	0.04	0.42*	0.25	0.17*
SOLUTION	0.63**	0.27	0.25**	0.39	0.26	0.15
Design	-0.90	0.58	-0.35	0.46	0.55	0.18
Advertising	0.30	0.41	0.12	0.04	0.40	0.02
Machine & process engineering	-0.07	0.39	-0.03	0.11	0.39	0.04
Electrical engineering	-0.22	0.41	-0.09	-0.69	0.44	-0.27
Management consulting	0.13	0.52	0.05	-0.11	0.51	-0.04
Observations	149			150		
Log Likelihood	-80.5			-85.4		
McFadden's pseudo R^2	0.24			0.17		
% of correct predictions	72			68		
LR test value for knowledge variables (p-value)	6.0	(0.20)		14.7**	(0.005)	

Notes: Estimation method is Probit maximum likelihood using Limdep econometric software. ** implies 5% significance, * implies 10% significance. R&D services is the reference industry. There are more item-nonresponding firms for the indicator IMPROVEMENT than for NEW SERVICE, hence the difference in the numbers of observations. Marginal effects are computed at means.

Contrary to studies of manufacturing industries, firm size and export orientation are not significant factors in our study of service improvement. In the case of incremental improvements, however, access to resources of a parent firm or a larger business group appears to be beneficial. Perhaps innovation scale effects in knowledge-based services depend not on the size of the business itself but on the sharing of knowledge within a larger network. Interestingly, systematic R&D activities are beneficial for service improvements but not for introductions of new services. Thus, contrary to recent conjectures about the nature of service innovation activities (e.g., Sundbo 1997), R&D does play a significant role in service innovation, although its impact may differ from that in manufacturing industries.

Among the knowledge variables, EDUCATION, TEAM, and SOLUTION consistently are positively associated with innovation success, although significance varies with the dependent variable. Codified collective knowledge embodied in the service solutions strategy is relevant for incremental innovators (IMPROVEMENT), while for firms that introduced completely new kinds of services (NEW SERVICE), having highly educated employees (explicit individual knowledge) and *not* being an EXPERT skills provider (i.e., not relying on tacit individual knowledge) are the most important elements of knowledge. Collective codified knowledge in the form of team routines is positively associated with NEW SERVICE too, but it is significant only at the 90% level of confidence. We assessed the specification with a likelihood ratio test. Including knowledge variables in the model is statistically supported in the model for NEW SERVICE but not for IMPROVEMENT. Thus we can significantly explain service firms' new service development performance using our measures of the four types of knowledge, but this explanation for service improvements is not quite statistically supported.

Table 4 includes the LICENSING variable to assess the impact of an alternative proxy for explicit collective knowledge. Both service solutions and out-licensing correlate positively with service improvements, but now the significance of SOLUTION is slightly reduced due to the correlation between these two variables. In contrast, licensing is not associated with new service introductions. Including LICENSING in the model is strongly supported by the likelihood ratio test in the model for IMPROVEMENT but not in the model for NEW SERVICE. The potential problem with this variable, however, is that it may be endogenous to the service innovation process itself, although in that case one would expect it to more significantly explain new service introductions.

Table 4 Technology licensing as an alternative measure of explicit organizational knowledge

Dependent variable:	IMPROVEMENT			NEW SERVICE		
	Coeff.	Std. error	Marginal effects	Coeff.	Std. error	Marginal effects
Constant	-1.37**	0.45	-0.53**	-0.78**	0.39	-0.31**
EMPLOYEES	0.002	0.002	0.001	0.0020	0.0015	0.0008
GROUP	0.83**	0.27	0.32**	0.34	0.25	0.13
EXPORTS	-0.68	0.50	-0.27	-0.57	0.49	-0.22
R&D DEPARTMENT	0.82**	0.35	0.32**	-0.05	0.30	-0.02
R&D INTENSITY	6.66*	3.89	2.58*	1.14	1.63	0.45
EXPERT	0.04	0.29	0.01	-0.64**	0.28	-0.25**
EDUCATION	0.61	0.50	0.24	0.92**	0.46	0.36**
TEAM	0.12	0.27	0.04	0.38	0.25	0.15
SOLUTION	0.52*	0.29	0.20*	0.39	0.27	0.15
LICENSING	1.00**	0.35	0.39**	0.38	0.29	0.15
Design	-0.68	0.59	-0.26	0.48	0.54	0.19
Advertising	0.74*	0.44	0.29*	0.05	0.40	0.02
Machine & process engineering	0.23	0.43	0.09	0.11	0.39	0.04
Electrical engineering	-0.08	0.45	-0.03	-0.69	0.44	-0.27
Management consulting	0.48	0.57	0.18	-0.09	0.51	-0.04
Observations	146			149		
Log Likelihood	-70.7			-102.3		
McFadden's pseudo R^2	0.30			0.18		
% correct predictions	0.78			0.67		
LR test for LICENSING variable (p-value)	13.4**	(0.0003)		1.7	(0.19)	

See notes for table 9.

These estimation results provide support for hypothesis 1 concerning the need to integrate knowledge resources within the organization. Emphasizing individual-based tacit knowledge alone can limit successful new service introductions. In contrast, individual explicit knowledge turns out to support innovation activities, perhaps because it can be more easily communicated, and it may further enhance communication by providing a shared knowledge base for knowledge integration and exchange.

Regarding our hypotheses about the roles of tacit versus explicit collective knowledge in innovation, results in tables 3 and 4 suggest that explicit collective knowledge (SOLUTION) is more closely associated with incremental improvements, whereas tacit collective knowledge (TEAM KNOWLEDGE) is associated with new service introductions that represent more radical departures from the existing knowledge base of the firm. Thus, our results support hypotheses 3a and 3b, rather than hypotheses 2a and 2b.

Extent of innovation

An alternative dependent variable to explore the robustness of earlier results on new service introductions is the share of sales revenue derived from these new services—a continuous variable bounded between 0 and 100%. Estimation method is thus Tobit maximum likelihood. This dependent variable is preferred by many scholars who use European innovation survey datasets because it at least partially measures the extent of innovativeness from the firm's perspective (Mairesse and Mohnen 2002).

The results in table 5 are largely aligned with those for new service introductions, with a few interesting differences. First, teams are a very significant factor behind more valuable (from the firm's point of view) new service introductions, while the role of education is slightly diminished here. The likelihood ratio test significantly supports inclusion of the four knowledge variables. Second, the most innovative service firms are strongly oriented toward domestic markets. In other words, highly export-oriented firms are unlikely to have a high share of sales originating from new services. These results thus reinforce those obtained earlier and support hypotheses 3a and 3b: Tacit collective knowledge supports more radical innovative departures from existing service activities, whereas codified collective knowledge supports incremental improvements to existing services.

Table 5 Determinants of sales share from service innovations

	Coeff.	Std. error	Coeff.	Std. error
Constant	-14.69*	8.30	-15.03*	8.54
EMPLOYEES	-0.023	0.028	-0.023	0.029
GROUP	5.20	5.06	5.08	5.16
EXPORTS	-21.45**	10.69	-21.68**	10.84
R&D DEPARTMENT	3.17	6.04	2.96	6.12
R&D INTENSITY	13.20	22.90	13.22	22.95
EXPERT	-5.95	5.57	-6.22	5.69
EDUCATION	16.16*	9.05	15.59*	9.15
TEAM	11.40**	5.20	10.88**	5.27
SOLUTION	3.99	5.38	4.31	5.46
LICENSING			3.67	5.73
Design	-4.96	10.98	-4.61	11.05
Advertising	-6.94	8.30	-7.43	8.42
Machine & process engineering	6.99	7.94	6.63	8.01
Electrical engineering	-15.42	9.22	-15.68*	9.35
Management consulting	-6.12	10.20	-6.61	10.32
Sigma (std. error)	22.74	(2.29)	22.87	(2.33)
Observations	146		144	
Log likelihood	-304.8		-299.75	
LR test for knowledge variables (p-value)	10.8**	(0.03)		
LR test for LICENSING variable (p-value)			0.41	(0.52)

Estimation method is Tobit maximum likelihood. ** implies 5% significance, * implies 10% significance.

5 Discussion and Concluding Remarks

This paper examines the effects of organizational knowledge on firms' performance measured in terms of innovation. It focuses on the distribution of business service firms' knowledge resources, that is, whether knowledge is held individually or collectively in the organization. Furthermore, whether knowledge is in a tacit or codified form matters for the shareability of knowledge. Thus, codification and collective ownership of knowledge both facilitate knowledge sharing in the organization and enhance the possibility for the firm to appropriate the returns to development investments.

Empirical results here suggest that collective knowledge improves the odds of successful innovation. Additionally, and perhaps surprisingly, explicit individual knowledge supports innovation. The only form of knowledge in the simple typology that is negatively correlated with innovation is individual tacit knowledge. This type of knowledge is the most difficult to combine with other knowledge assets, because it is deeply embodied in individuals' skills and practices and it is difficult to communicate to other employees. These empirical results obtained with the knowledge-intensive business service data are thus broadly aligned with the view of innovation as a process of recombining existing knowledge components. Moreover, we empirically contribute to the literature by identifying practices for combining knowledge and assessing their implications for the nature of innovation outcomes.

Literature on combinatory innovation—for example, Nonaka's (1994) work and recent research by Fleming (2001)—suggests that incremental improvement of products or services is more likely to be associated with cumulative, possibly tacit, learning. In contrast, more radical breakthroughs should be observed where combination of codified and less closely related knowledge components takes place. However, results in our study align more closely with Spender's (1996) conjecture and suggest that more significant departures from existing services are associated with tacit collective knowledge, measured by the importance of knowledge residing in teams, as opposed to that residing in individuals or technologies. Incremental improvements, on the other hand, are likely to be made by firms that base their competitiveness on codified service solutions or tradeable technologies.

The results obtained here thus imply that innovation, albeit a process of recombination, does not necessarily require codification to occur, even though codification can be a valuable knowledge management technique for other reasons, such as the possibility to participate in the markets for technology and the ability to cumulatively build on existing knowledge in organizational learning. In other words, codification may make organizational learning more efficient (Levitt and March, 1988), but is not a prerequisite for service innovation. Meanwhile, the result that codified service solutions are conducive to incremental service improvements makes sense in the product sequencing framework of Helfat and Raubitschek (2000). These authors argue that products and capabilities co-evolve over time. Existing products or service solutions thus serve as focal points for organizational learning. This may be the reason that incremental improvements are associated with codified services. However, these ideas would need to be more explicitly tested using different datasets to be more than speculative interpretations.

An interesting difference between innovation activities in business services and in manufacturing, the context in which most innovation research has been tested, is related to the organization of R&D. Our findings indicate that having a permanent R&D department or team—institutionalized R&D—is important for improvements of existing services but not for creation of completely new kinds of services. In contrast, new services tend to be introduced by firms with highly educated employees and team-based knowledge. It appears, then, that institutionalized R&D activities are more conducive for incremental improvements of existing service offerings, while departures from existing service activities require skilled workforce and effective team routines. This suggests a qualification of the propositions made in earlier research that R&D activities are relatively unimportant in service industries: Systematic service improvements may be effectively carried out through systematic R&D. However, the insignificance of R&D investment levels suggests that highly innovative service firms do not need to be highly R&D intensive, in stark contrast to results from the manufacturing sector.

To conclude, controlling for other firm and industry differences, this empirical study suggests that firms' strategies for knowledge creation and application have implications for their innovation performance. Assuming that knowledge assets can be classified with respect to both their individual or collective nature and their tacit or codified nature, then innovation in business services is associated with tacit and explicit collective knowledge and with explicit individual knowledge. In contrast, relying on individuals' tacit skills alone may hamper innovation. These empirical results on business service firms shed new light on the debate in organization studies concerning the strategic effects of tacitness and collectiveness of knowledge. Innovation benefits may be gained both from codifying knowledge and from making it appropriable at the organizational, as opposed to individual, level.

However, the mechanisms behind the effects of tacit and explicit organizational knowledge on innovation need to be further explored. Why exactly is tacit individual knowledge associated with new service development, while explicit individual knowledge is associated with incremental service improvement? Also, this empirical analysis is cross-sectional and thus results are potentially subject to endogeneity problems, which should be dealt with as larger and preferably longitudinal datasets become available to researchers. Finally, testing the hypotheses with data from manufacturing industries would gauge the extent to which our results are specific to the service sector.

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Appendix

Table A1 Estimation variables

	Variable	Description	Expected sign
Dependent variables	IMPROVEMENT	Significant service improvements (0/1)	
	NEW SERVICE	New service introductions (0/1)	
	INNOSALES	Share of newly introduced services in sales (0-100%)	
Basic firm characteristics	EMPLOYEES	Number of employees 1999	+
	EXPORTS	Export intensity 1999	+
	GROUP	Subsidiary or member in a business group (in other words, more than 50% ownership by another company)	+
Knowledge assets	EXPERT	Expert skills (0/1) (individual tacit knowledge)	–
	EDUCATION	Share of employees with higher education (%) (individual explicit knowledge)	n.a.
	TEAM	Competitiveness based on teams' knowledge (0/1) (collective tacit knowledge)	+
	SOLUTION	Service solutions (0/1) (collective explicit knowledge)	+
	LICENSING	The firm licenses technology to external parties (0/1) (collective explicit knowledge)	+
Service development activities	R&D DEPARTMENT	The firm has a permanent R&D team or department (0/1)	+
	R&D INTENSITY	R&D investments/sales (%)	+
Industry dummies			

n.a. = not available

Table A2 incorporates information from the Finnish Community Innovation Survey (CIS) for service industries (SF 1998) that included the technical services industry (NACE 742: engineering and architectural services) but not other business service industries studied here. Available descriptive statistics from this source for technical services are displayed in the last column of table A2. Compared to this data source, the survey data of engineering firms used here include smaller and less profitable firms, but these firms are on average more innovative. This suggests that the possible large firm bias mentioned earlier is negligible.

The discrepancy concerning innovativeness of surveyed engineering firms is partly due to the fact that the CIS material from Statistics Finland includes architectural and other construction-related technical services, which tend to be less innovative. This is confirmed by removing firms related to construction and architecture services from the CIS innovation survey sample: now 50% of engineering firms are innovative in the CIS data. The business service survey data used here fall between these two numbers from the CIS, suggesting that no substantial innovativeness bias exists.

In comparison with the technical services firms in the Innovation Survey sample of Statistics Finland, R&D investments are lower in the current dataset, although the share of R&D investing firms is higher. On the whole, the data used here do not appear to be biased toward more R&D intensive firms.

Table A2. Descriptive statistics by industry

	Industrial design	Adver-tising	Management consulting	R&D services	Machine, process engineering	Electrical engineering	Engineering services combined	Technical services in Finnish CIS (1996)
Sales (million Finnish markka 1999)	2.6	42.1	35.8	14.1	31.3	9.3	22.2	46.1
Employees (1999)	6	34	52	32	75	23	52	65
Export share (1999, %)	1.6	0.9	7.4	28.8	21.3	10.5	16.6	21.7
Business group (% of firms)	18	51	44	24	44	24	35	n.a.
New service introductions (% of firms)	55	47	61	48	46	27	38	33.8
Service improvements (% of firms)	18	64	82	50	54	40	48	n.a.
Share of sales from innovative services (%)	6.5	5.1	7.3	5.3	7.2	2.4	5.1	n.a.
R&D investments > 0 (% of firms)	27	48	67	43	61	65	57	39
R&D department or team (% of firms)	20	12	21	24	24	20	22	n.a.
R&D investments/sales (%)	2.2	1.3	2.1	2.3	2.7	12.7	2.2	3.5
Response rate (%)	41	41	35	48	51	40	46	71 (all service industries)
Observations	11	44	18	21	39	30	69	65

n.a. = not available.

Table A3 Knowledge resources by industry

	Industry means					
	Industrial design	Advertising	Machine & process engineering	Electrical engineering	Management consulting	R&D services
Individual explicit: Higher education degrees (% of employees)	69.0	24.5	22.0	21.6	67.0	37.1
Individual tacit: Expert skills (survey mean; scale 0–3)	2.4	2.3	1.9	1.9	2.1	2.1
Organizational explicit: Service solutions (survey mean; scale 0–3)	0.6	1.3	1.3	1.2	1.9	0.9
Technology licensing (out) (0/1)	0.20	0.07	0.24	0.24	0.22	0.29
Organizational tacit: Competitiveness based on knowledge in teams (survey mean; scale 0–3)	2.0	2.6	2.1	2.1	2.2	2.3
R&D intensity R&D investments per sales (%)	2.2	1.4	2.1	2.3	3.1	8.1

Scale: 0 (not important) – 3 (very important), except for higher education levels (%), technology licensing (0/1 binary variable), and R&D intensity (%)

Table A4 Descriptive statistics for estimation variables

Variable	Mean	Std. dev.	Min.	Max.	Obs.
IMPROVEMENT	0.54	0.50	0	1	163
NEW SERVICE	0.45	0.50	0	1	166
INNOSALES	5.8	13.7	0	100	161
EMPLOYEES	41	82	1	590	163
GROUP	0.38	0.49	0	1	165
EXPORT	0.12	0.26	0	1	168
EXPERT	0.30	0.46	0	1	168
EDUCATION	32.8	31.1	0	100	162
TEAM	0.38	0.49	0	1	168
SOLUTION	0.37	0.48	0	1	168
LICENSING OUT	0.19	0.39	0	1	163
R&D DEPARTMENT	0.20	0.40	0	1	162
R&D INTENSITY	0.033	0.096	0	4	161

Table A5 Correlation matrix for estimation variables

	1	2	3	4	5	6	7	8	9	10	11	12
1. IMPROVEMENT	1											
2. NEW SERVICE	0.42	1										
3. INNOSALES	0.20*	0.46*	1									
4. EMPLOYEES	0.17*	0.17*	0.00	1								
5. EXPORT	-0.06	-0.10	-0.08	0.03	1							
6. GROUP	0.28*	0.13	0.02	0.27*	0.15	1						
7. EXPERT	-0.03	-0.13	-0.03	0.03	0.05	0.11	1					
8. EDUCATION	0.11	0.17*	0.14	0.00	0.01	0.02	0.09	1				
9. TEAM	0.04	0.14	0.05	0.17*	-0.14	0.10	0.09	-0.01	1			
10. SOLUTION	0.09	0.00	-0.02	-0.01	-0.08	-0.01	0.08	-0.05	0.09	1		
11. LICENSING OUT	0.20*	0.11	-0.04	0.07	0.08	-0.03	-0.11	0.04	-0.01	0.04	1	
12. R&D DEPARTMENT	0.24*	0.08	0.10	0.10	0.13	0.01	-0.06	0.11	0.04	0.08	0.07	1
13. R&D INTENSITY	0.17*	0.06	0.07	-0.06	0.32*	0.05	-0.16*	0.10	-0.04	-0.07	0.19*	0.31*

* implies significance at the 5% level.