

**TUTKIMUSRAPORTTI – RESEARCH REPORT 191**

Ville Ojanen

**ON THE INNOVATION CAPACITY OF TECHNOLOGY-RELATED KNOWLEDGE-INTENSIVE BUSINESS SERVICES**

**A case study of the technology and engineering consulting (TEC) sector in Singapore**

Tuotantotalouden osasto  
Department of Industrial Management

Lappeenrannan teknillinen yliopisto  
Lappeenranta University of Technology

FI-53851 Lappeenranta, Box 20, Finland

ISBN 978-952-214-488-1 (paperback)  
ISBN 978-952-214-489-8 (pdf)  
ISSN 1459-3173

Lappeenranta 2007

## **ABSTRACT**

Even though the research on innovation in services has expanded remarkably especially during the past two decades, there is still a need to increase understanding on the special characteristics of service innovation. In addition to studying innovation in service companies and industries, research has also recently focused more on services in innovation, as especially the significance of so-called knowledge intensive business services (KIBS) for the competitive edge of their clients, other companies, regions and even nations has been proved in several previous studies.

This study focuses on studying technology-based KIBS firms, and technology and engineering consulting (TEC) sector in particular. These firms have multiple roles in innovation systems, and thus, there is also a need for in-depth studies that increase knowledge about the types and dimensions of service innovations as well as underlying mechanisms and procedures which make the innovations successful. The main aim of this study is to generate new knowledge in the fragmented research field of service innovation management by recognizing the different types of innovations in TEC services and some of the enablers of and barriers to innovation capacity in the field, especially from the knowledge management perspective. The study also aims to shed light on some of the existing routines and new constructions needed for enhancing service innovation and knowledge processing activities in KIBS companies of the TEC sector.

The main samples of data in this research include literature reviews and public data sources, and a qualitative research approach with exploratory case studies conducted with the help of the interviews at technology consulting companies in Singapore in 2006. These complement the qualitative interview data gathered previously in Finland during a larger research project in the years 2004-2005. The data is also supplemented by a survey conducted in Singapore. The respondents for the survey by Tan (2007) were technology consulting companies who operate in the Singapore region. The purpose of the quantitative part of the study was to validate and further examine specific aspects such as the influence of knowledge management activities on innovativeness and different types of service innovations, in which the technology consultancies are involved.

Singapore is known as a South-east Asian knowledge hub and is thus a significant research area where several multinational knowledge-intensive service firms operate. Typically, the service innovations identified in the studied TEC firms were formed by several dimensions of innovations. In addition to technological aspects, innovations were, for instance, related to new client interfaces and service delivery processes. The main enablers of and barriers to innovation seem to be partly similar in Singaporean firms as compared to the earlier study of Finnish TEC firms.

Empirical studies also brought forth the significance of various sources of knowledge and knowledge processing activities as the main driving forces of service innovation in technology-related KIBS firms. A framework was also developed to study the effect of knowledge processing capabilities as well as some moderators on the innovativeness of TEC firms. Especially efficient knowledge acquisition and environmental dynamism seem to influence the innovativeness of TEC firms positively. The results of the study also contribute to the present service innovation literature by focusing more on “innovation within KIBS” rather than “innovation through KIBS”, which has been the typical viewpoint stressed in the previous literature. Additionally, the study provides several possibilities for further research.

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## 1 INTRODUCTION

### Background and motives of the study

Small advanced economies - such as Singapore or Finland - are strongly dependent on leveraging on innovations (e.g. OECD, 2006; Parayil, 2005; Wong and Singh, 2004, Howells and Tether, 2004). The search for appropriate innovation policies, patterns and practices is a global phenomenon, which can be seen also on a larger scale. For example, promoting the development of innovation policies was one of the main themes during the 2006 EU presidency of Finland<sup>1</sup>. Similarly, nations all over the globe, also in Asia, have put more emphasis on various aspects of innovation promotion. Innovations can happen in various forms and in various industries, in manufacturing but also increasingly in services (Tether, 2005), certain significant sub-sectors of which are the focus of this paper.

Research on innovation in services has expanded remarkably especially during the past two decades (see Xin et al., 2006). Research has shown that for some parts, the characteristics of innovations in services are similar to those of manufacturing and pure physical products, but for many parts they are different (Coombs and Miles, 2000; Drejer, 2004; Howells and Tether, 2004). The differences are in many cases said to be caused by typical service characteristics, such as intangibility, heterogeneity, inseparability and perishability<sup>2</sup> (e.g. Edvardsson et al, 2005; de Jong et al., 2003). Earlier, services were often considered as non-innovative or at least innovating differently than pure industrial manufacturing organizations (e.g. Tether, 2005). Today, the significance of service-related innovations has been understood, and innovations in services have been promoted, as the services sector as a whole in many industrial countries has grown remarkably, being typically about two thirds of the gross domestic product (Tether, 2005).

In addition to studying innovation in service companies and industries, research has also recently focused more on services in innovation, as especially the significance of so-called knowledge intensive business services (KIBS) for the competitive edge of their clients, other companies, regions and even nations has been proved in several previous studies (Miles, 2003a; Howells and Tether, 2004; Hipp and Grupp, 2005). Knowledge intensive services in business-to-business environments differ significantly from services focusing on individuals and consumer markets. Still, there are differences also inside the KIBS sector, which can be seen in earlier studies (Leiponen, 2006; Wong and Singh, 2004). For instance, technology and engineering consultancies (TECs) have their own special characteristics when compared to some other KIBS sectors and professional services, such as accounting and legal services, which include less technology- and innovation-related elements (Gann and Salter, 2003). Innovation studies focusing on particular services sectors by taking their special characteristics into account and clarifying how different types of innovations actually take place in services and which kind of factors are most influential in innovations are still relatively rare. There are studies showing that existence of KIBS enhances the economic performance of certain sectors and regions (e.g. Leiponen, 2001; Miles, 1999). In addition to the studies focusing on the services' impact at regional or industry levels, there is also a need for in-depth studies that increase knowledge about the types and dimensions of service

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<sup>1</sup> The themes for the EU presidency of Finland in 2006 were presented on the web site [http://cordis.europa.eu/finland/presidency/priorities\\_en.html](http://cordis.europa.eu/finland/presidency/priorities_en.html)

<sup>2</sup> These characteristics are typically abbreviated as IHIP.

innovations as well as underlying mechanisms and procedures which make the innovations successful (see e.g. Tidd and Hopkins, 2006). This research aims to contribute to filling this research gap for some parts.

### **Focus and objectives**

The focus of this study is especially on the technical engineering and consulting sector's knowledge-intensive services. These kinds of services have an increasing role also in typical traditional industry clusters, e.g. construction and engineering and basic manufacturing such as pulp and paper, as well as petrochemical and other process industries. These technology and engineering consulting services, which can also be abbreviated as TECs (see e.g. Tidd and Hopkins, 2006), belong to a larger group of T-KIBS (technology-based knowledge-intensive business services) (Miles, 2003b). They are in this context considered as services and/or companies that have high-level technological and/or other competencies based on highly educated and motivated work-force as well as accumulated special knowledge, and which especially play a significant role in the long-term innovation development in their industry. In spite of their significance for innovation, several companies offering these types of knowledge-intensive professional services operate in a rather conventional business environment with the help of the working routines that have been developed during several years in the company. Due to the lack of time and other resources, the companies' R&D and innovation development intensity has been relatively low (e.g. Miles, 2003b), despite the recognized great potential for innovating. Therefore, there is a real need for research on new types of methods for systematically promoting and assessing innovation activities in technology-related knowledge-intensive services.

The main aim of this study is to generate new knowledge in the fragmented research field of service innovation management by recognizing the different types of innovations in technology and engineering consulting services and some of the enablers of and barriers to innovation capacity in the field, especially from the knowledge management perspective. The study also aims to shed light on some of the existing routines and new constructions needed for enhancing service innovation and knowledge processing activities in KIBS companies of the TEC sector. Secondly, it also aims to analyze and compare some similarities and differences in the above-mentioned areas of service innovation management in the analysis between research results from the two countries in which knowledge-intensive professional services such as technical consulting services and innovations play a significant role. The countries studied, Finland and Singapore, are both known for their small size, advanced economy and high rating in international competitive measurements (WEF, 2006). Other geographical areas are left outside the scope of this study.

### **Research methodology**

The research includes multiple samples of data. In addition to literature reviews and public data sources, a qualitative research approach with exploratory case studies has been taken with the help of the interviews conducted at technology consulting companies in Singapore in 2006. These complement the qualitative interview data gathered previously in Finland during a larger research project in the years 2004-2005. The data is supplemented by a survey

conducted in Singapore. The respondents for the survey by Tan (2007) were technology consulting companies who operate in the Singapore region. The purpose of the quantitative part of the study was to validate and further examine specific aspects such as the influence of knowledge management activities on innovativeness and different types of service innovations, in which the technology consultancies are involved.

The complexity of the whole research topic and novelty in this particular context required choosing qualitative, explorative case studies (see Yin, 1994) to be used as the main methodology at the early stages of the research. With the help of the qualitative data, one can preserve chronological flows, see which events led to which consequences, and derive fruitful explanations (Miles and Huberman, 1994). The early stage of the present study is conducted as a multiple holistic case study (Yin, 1994). Generally, the terms qualitative and case study are often used interchangeably, but actually, case study research can involve qualitative data only, quantitative only, or both (Eisenhardt, 1989; Yin, 1994). In the terms of triangulation (Yin, 1994; Patton, 1987), the present study has utilized multiple sources of evidence by using quantitative data to supplement but also to validate the assumptions and results from the qualitative type of case studies and interviews.

## 2 THEORETICAL FRAMEWORKS ON INNOVATIONS IN SERVICES AND SERVICES IN INNOVATION

While the debate continues on whether the innovation theories and practices related to the classic manufacturing industries are applicable to service industries or not, it is essential to note that many authors have recently stressed that traditional boundaries between manufacturing and services are becoming obsolete (e.g. Gann and Salter, 2003; Drejer, 2004). There are new forms of production for supplying physical products together with intangible services (Gann and Salter, 2003). In their earlier study, Coombs and Miles (2000) distinguished three approaches to studying and defining innovation in services: 1) the assimilation approach (services treated similarly to manufacturing), 2) the demarcation approach (services innovation distinctly differently from innovation in manufacturing) and 3) the synthesis approach, which suggests that service innovation brings forth thus far neglected elements of innovation that are relevant for both manufacturing and services (see e.g. Drejer, 2004). The third approach is increasing its significance at the same time when dichotomies and boundaries between manufacturing and services are becoming blurred. Many traditional manufacturing companies have increased their services, while service-providing firms tend to compete also with tangible products (see e.g. Davies et al., 2006). For instance, paper machinery suppliers have developed maintenance and other services for the whole lifecycle of a paper mill. At the same time, increased use of ICT and productivity requirements have been motives for several service organizations who have started to "productize" their services and have developed also tangible service products e.g. in the form of software in order to support their own and customers' operations (e.g. Ojanen et al., 2007).

This chapter aims to shed light on various definitions and theoretical foundations in the fragmented research field of service innovation. Here, we not only concentrate on innovations, their types and novelty taxonomies etc. related to innovation in services, but we also discuss the services in innovation, especially particular aspects of technology-related knowledge-intensive business services, which have a significant role especially in their client industries by being sources, facilitators or even co-producers of innovation (see den Hertog, 2000).

### **Innovation in services**

In knowledge-intensive companies such as technical engineering consultancies, value creation takes place in the form of **services**, which, according to the widely known definition of Grönroos (2001), are *activities or series of activities of a more or less intangible nature that normally, but not necessarily, take place in interactions between the customer and service employee and/or physical resources and/or systems of the service provider, which are provided as solutions for customer problems.*

Another definition can be stated as follows:

*"To produce a service, therefore, is to organize a solution to a problem (a treatment, an operation) which does not principally involve supplying a good. It is to place a bundle of capabilities and competencies (human, technological, organizational) at the disposal of a client and to organize a solution, which may be given to varying degrees of precision."* (Gadrey et al., 1995).

Actually, there are various definitions of services. In several definitions, keywords involved in the services definitions are said to be *activities, deeds or processes and performance* (Edvardsson et al., 2005; Lovelock, 1991; Zeithalm and Bitner, 2003; Vargo and Lusch, 2004). Grönroos' definition (2001) includes three major elements: 1) activities, 2) interactions and 3) solutions to customer problems. Grönroos (2001) identifies two different aspects in categorizing services, the type of service and the type of customer. A service is either a professional service or another type of service and it can be offered to either customers or organizational buyers.

On the basis of a literature research and an expert survey, Edvardsson et al. (2005) came to the conclusion that IHIP (intangibility, heterogeneity, inseparability and perishability) characteristics have to be critically assessed and that they are not as "universal" as they were considered in service literature in the past. In relation to this critical assessment of characteristics, Vermeulen and van der Aa (2003) have suggested that of the four IHIP characteristics heterogeneity and perishability do not have a great impact on the organization of an innovation process, because physical products may also be heterogeneous and new services can actually be developed in advance. Additionally, Edvardsson et al. (2005) argue that the essence and characteristics of a service strongly depend on the perspective. They see service itself as a value creation perspective rather than a category of market offerings and suggest focusing on value co-creation with customers (Edvardsson et al., 2005).

According to the definition of Eurostat (1995), innovations in service sectors comprise new services as well as significant changes in existing ones or their production or delivery. Still, most of the previous research has been qualitative by nature and has focused more on technological innovation, not so much on e.g. organizational types of innovations (see e.g. Xin et al., 2006; Tether, 2005).

Innovations in services can be analyzed in several ways, e.g. on the basis of the degree of novelty, and different types and dimensions of innovation. Theories and typologies of innovations have traditionally distinguished between product and process innovations (e.g. Utterback, 1994; Schumpeter, 1934). In attempts to utilize this distinction for classifying service innovations, we come to inseparability as a typical service characteristic: Services typically have a process character, and therefore, the production process cannot be completely separated from the concept of a service product. In the service delivery process, there is often close interaction between producers and customers, and many services are, in fact, produced at the moment of consumption. The difficulty to change the product without changing the procedure makes the clear distinction between the process and the product in services nearly impossible (van der Aa and Elfring, 2002; Sundbo and Gallouj, 1998).

However, variations and extensions of this type of taxonomy of process and product innovations have been utilized by authors in the service innovation literature followed by the above-mentioned assimilation approach and Schumpeterian models for innovation typologies. According to Eurostat (1995), product innovations are services whose intended use or performance characteristics differ significantly from those already produced, and process innovations are new or significantly improved ways of producing and delivering services. Miles et al. (1995) argue that in addition to product and process innovation, the delivery of the service to the client can be a site of innovation. Sundbo and Gallouj (1998), in turn, distinguished four main types of innovation: product innovation, process innovation, organizational innovation and market innovation. Here, organizational innovation refers to



new, general forms of organization or management, process innovations enhance service production processes or delivery processes, and market innovations include e.g. finding a new market segment, or entering another industry and its market. In the literature, organizational types of innovations are also referred to as “management innovations” (Birkinshaw and Mol, 2006). According to Sundbo and Gallouj (1998), so-called “ad hoc innovation” could be added to this typology, as it seems to be important especially in knowledge-intensive business services. This type of innovation is essentially “co-produced” by the client and the service provider and it is defined as the interactive construction of a solution to a particular problem posed by the client.

In the study of Gadrey, Gallouj and Weinstein (1995), different types of service innovations are identified in three service sectors. For example, in the insurance sector the authors observe 1) innovations in “service products”, 2) architectural innovations, 3) innovations which modify the “service product” and 4) innovations in processes and organization for an identical or almost identical service. On the other hand, in electronic information services the types of innovations are 1) the creation of a new product or new service, 2) innovations in the improvement of products or services and 3) process innovations. In addition, van der Aa and Elfring (2002) distinguish three main categories of service innovations on the basis of literature. The first category includes the innovation process or the ‘new product development’ process in a service firm, the second category deals with the role of information and communication technologies in services, and the third category focuses on the various forms of innovation, especially organizational and technological innovations (Ojanen et al., 2007).

Existing literature has also tried to explain service innovation as a process (e.g. Gruner and Homburg, 2000; Alam, 2002). De Jong et al. (2003) have also aimed to study new service development (NSD) as a process that can be managed. The process is for most parts similar to those presented in the new product development (NPD) literature (e.g. Cooper, 1993), but they have divided it into two main stages, searching and implementation, both including several activities (see Figure 1). The process together with direct and indirect success factors provide preconditions for service innovations including several dimensions, and innovative performance (de Jong et al., 2003).

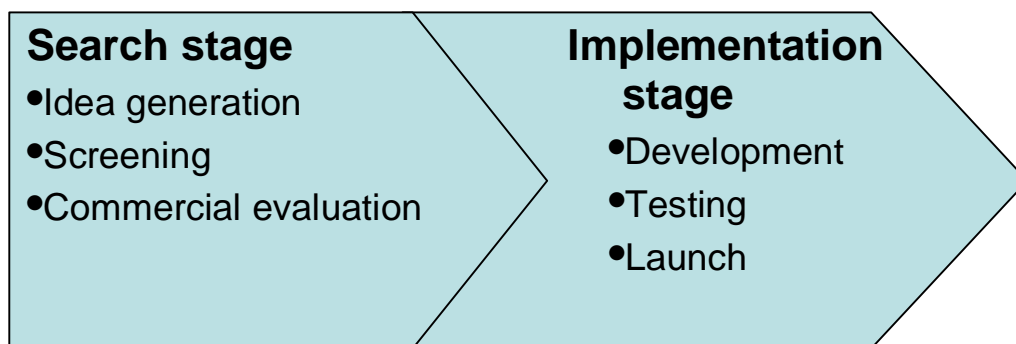


Figure 1. New service development process (adapted from de Jong et al., 2003).

The variety of taxonomies reflects the lack of well-established frameworks and taxonomies in service innovation research. It can, however, be said that service innovations encompass several dimensions – besides product innovations, researchers have identified various types of

process innovations, organizational innovations, market innovations, service delivery innovations, etc. (e.g. Miles, 2003b). For instance, in their quantitative study of German service firms, Hipp, Tether and Miles (2003) show that many of the service firms have all types of innovation activities; service product innovations, process innovations and organizational innovations. At the same time, it should also be noted that most service innovations appear to have characteristics of more than one dimension. It is also argued that there are remarkable differences in the specific patterns of these innovations: for example, introducing a new service product into one market may have different requirements than offering the same product in some other market (den Hertog, 2000). In order to analyze the diversity of innovations in greater detail and in a structured way, den Hertog (2000) proposes a four-dimensional model of service innovation: the service concept, the client interface, the service delivery system or organization, and technological options (see Figure 2 below).

Innovativeness in the first dimension, in the service concept, is related to the content and characteristics of a new or renewed service. Existing service concepts may be novel and innovative in applications within a particular market. In addition, service firms often choose to imitate competitors' innovations. Therefore, changes in the service concept are an important source of adaptations, and firms need to adjust their service concepts on the basis of the characteristics of existing and competing services (de Jong et al., 2003). Examples of the service concept innovations may include e.g. call centre services and particular ICT services (den Hertog, 2000; de Jong et al., 2003) or "productized services" (Ojanen et al., 2007).

The second dimension in the framework is the client interface, which is quite often the focus of service innovation activities. This concerns especially knowledge-intensive business services in which clients partake in the service production process, and the service product itself offers support for the client's innovation (e.g. Mills and Morris, 1986; den Hertog, 2000; van der Aa and Elfring, 2002). In the case of co-production of services, it is sometimes difficult to locate the innovations within the service supplier or the client. For example, it is not unusual that service firms such as TECs position their staff within client organizations for a period of time (Ojanen et al., 2007). Other examples of innovations in the client interface may, for instance, be related to new electronic data systems influencing the information and knowledge transfer between the supplier and the client.

The service delivery system or organization is the third dimension; innovation here consists of adjustments and rearrangements in the organization form and service delivery system. This may include e.g. new internal processes that enhance the performance of the service workers and/or allow them to develop and offer new innovative services. Employee training and the development of interpersonal capabilities and skills are among the means that facilitate innovations and non-conventional solutions to practical problems. This dimension is often directly related to the linkage between the service provider and its client (the second dimension discussed above), as delivery is one specific type of interaction across the client interface. One example of innovation in the service delivery system is the introduction of e-commerce, which may require considerable business process re-engineering.

Technological options in service innovations are the focus in the fourth dimension. As the discussion above related to innovation in services clearly shows, service innovations often do not involve technological innovations. Instead, technology – especially IT – often has a facilitating or enabling role in service innovation, for example in engineering consultancies who provide innovative solutions to their clients. ICT also makes new types of "virtual working environments" in technical engineering and consulting possible (Ojanen et al., 2007).

Additionally, technology facilitates the maintenance of networks with customers and partners inside and outside the firm (Kandambully, 2002). On the other hand, changes in technological options may also be forced by changes in the other dimensions. An example of innovation with a strong technological component could be a tracking and tracing system in transport services, which enables service providers to manage their services more efficiently (den Hertog, 2000).

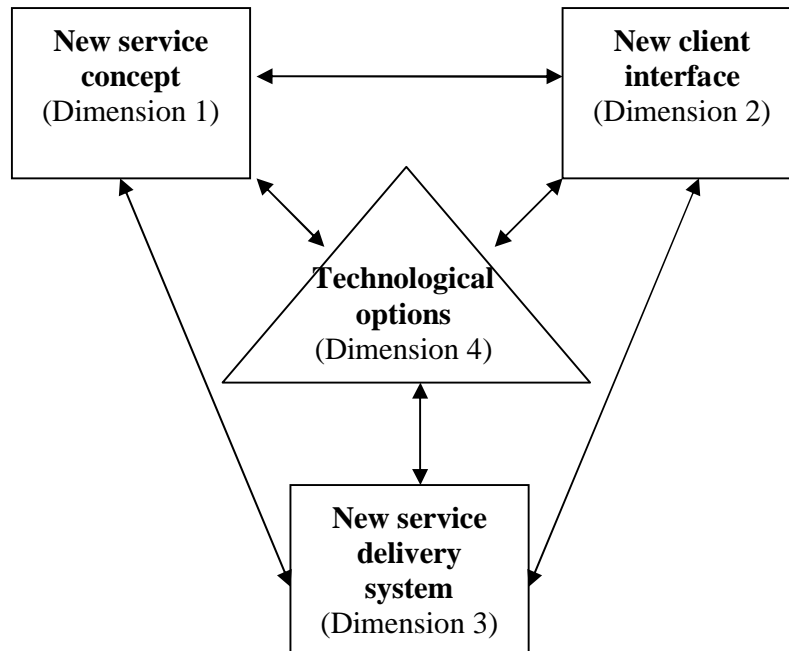


Figure 2. A four-dimensional model of service innovation (adapted from den Hertog, 2000).

This model can also be further grouped into technological and non-technological dimensions (den Hertog et al., 2003). The non-technological dimensions include the introduction of a new service concept, a new client interface, and a new service delivery system in terms of a new working routine, organizational concept, or back-office set up. The technological dimension relates to investment in ICT. Den Hertog et al. argue that ICT facilitates the non-technological dimensions of innovation, but the latter also facilitate the application of ICT. This suggests that the generation and diffusion of information technologies should clearly be included in both the definition of innovation and its expenditures (Evangelista and Sirilli, 1998).

The framework provides only one possibility to assess the activities, as all dimensions of innovations are difficult to be categorized to be examples of just one dimension. However, the original framework of den Hertog (2000) also provides a view to interdependencies between different dimensions. Typically, most service innovations are combinations of different dimensions (e.g. Hipp and Grupp, 2005). For example, den Hertog (2000) argues that developing a completely new service may require a new service delivery system, changes in the way employees work or relate to customers, and modifications in the way IT is used in business processes. Moreover, a new service concept may also be involved. Providing clear examples of the above-mentioned dimensions is, therefore, very difficult.

It is important to recognize the possible linkages between different dimensions. People working in marketing, service distribution and organization development almost certainly

have to deal with these cross-linkages: introducing a new service concept, for instance, requires marketing expertise, and changes in the client interface require knowledge of the service delivery system. If a firm aims at improving cost efficiency, quality control, etc., the analysis of the relationships between the four dimensions becomes even more important. It is obvious that the weights of the individual dimensions, as well as the importance of the various linkages between them, vary across individual services, innovations and firms. Also the inputs required to link the dimensions differ according to the type of service (de Jong et al., 2003; den Hertog, 2000). In addition, given the role of many services to co-produce innovations together with other organizations (especially clients) (den Hertog, 2000) and be “knowledge brokers” between organizations (Ofek and Sarvary, 2001; Hargadon, 1998), it is also essential to recognize the linkages of knowledge flows between organizations in different dimensions.

Factors influencing service innovations have also been investigated widely in the literature. The existing results indicated that many of the success factors for services are similar to those found for manufacturing products (De Brentani, 1989, 1991; Cooper and De Brentani, 1991). These include, for instance, the strategic focus on innovation (Edvardsson et al., 1995; Johne and Storey, 1998), the appropriate resource commitment (Edgett, 1994; De Jong and Vermeulen, 2003), the management support (Martin and Horne, 1995), and the formal new service development process (Edvardsson et al., 2000; Froehle et al., 2000; de Brentani, 2001). However, services entail some important differences which companies must take into account when they go about service innovation (de Brentani, 2001). When compared to the common success factors of product innovation, some factors may be more important in service innovation. These are e.g. highly trained experts in the company (Johne and Harborne, 1995; Evangelista and Sirilli, 1998), the learning environment in the company (Sundbo, 1997; den Hertog et al., 2003; Herrmann et al., 2006), as well as customer involvement in the service innovation process (Martin and Horne, 1995; Bitner et al., 2000; Herrmann et al., 2006).

Here, we also focus on innovation as a knowledge management process (Madhavan and Grover, 1998) and a learning process (Witt, 1993). Innovation should be the result of the generation, acquisition, and use of new or new combinations of technologies or other substantive investments in new knowledge (Eurostat, 1995; Witt, 1993; Nonaka and Takeuchi, 1995). This is especially the case in knowledge-intensive services, where the competitive advantage is strongly dependent on the ability to codify individual tacit knowledge into collective knowledge to provide service innovations (e.g. Leiponen, 2006). In addition to a firm’s own knowledge stock, its success is dependent on the absorptive capacity, which according to the definition of Cohen and Levinthal (1990) is the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends. It is largely a function of the firm’s level of prior related knowledge, which includes integration of its own knowledge stock with the acquisition of external knowledge. The focus in the next section is on knowledge-intensive business services, which provide an interesting research area for studying the significance of managing both internal and external knowledge for service innovations.

### **Services in innovation: focus on new technology-based KIBS**

Services are different from manufacturing, but inside the service sector there is a wide variety of different types of sub-sectors (e.g. Tether and Hipp, 2002; Tether, 2003). Knowledge-

intensive and technology-related business-to-business services provided by e.g. engineering and technology consultancies can be very different by nature and different in their innovation-intensiveness from many other e.g. consumer-related services.

Knowledge-intensive business services (KIBS) have several roles in service innovation. These services have especially been said to be significant for innovation promotion of their clients, e.g. manufacturing companies (see e.g. Miles, 2003b). KIBS cover a wide range of services. Many professional services can be considered knowledge-intensive whether they are technology-based or not (den Hertog, 2000). Miles et al. (1995) make a distinction between two groups of KIBS. The first group consists of traditional professional services such as marketing and advertising, management consultancy as well as accounting and bookkeeping, which are liable to be intensive users of new technology. The other group is new technology-based KIBS (also called T-KIBS), including e.g. computer networks, software, design involving new technology and technical engineering. The common factor for both these groups is that KIBS rely heavily on the professional knowledge of scientists, engineers and experts of all types. They either supply products which are primary sources of information and knowledge to their users or produce services as intermediary inputs to knowledge generating and information processing activities of their clients (Miles et al., 1995).

The main idea of sharing knowledge in any knowledge-intensive company is to recycle as much usable knowledge as possible by using databases and information systems to store concepts and tools for public access. The services of a knowledge firm are often tailored to meet specific and individual needs of the client. The reason for this is the assumption that standardized services do not have the same appeal as customized services. Each client wants to feel the “uniqueness” of the solution. However, most firms usually offer standardized services adapted to meet the requirements of the client (Petersen and Poufelt, 2002).

As knowledge-intensive business services are often a joint production of the service provider and the client, the quality of the service product largely depends on the nature of the interaction between these two parties and on the quality of the communication process that is involved (e.g. He, 2003). KIBS provide a fusion point between general scientific and technological knowledge, and the local requirements and problems of their clients. They act as catalysts promoting this fusion of more generic knowledge and more tacit knowledge located within the daily practices of the companies and sectors they serve (den Hertog, 2000).

KIBS play a crucial role in the development of new products, services and processes since they act as carriers, shapers and creators of innovations which can be technological or managerial by nature. Intermediary services such as purchase, operation support and maintenance constitute important inputs into modern production processes. The importance of end-user services grows since customers typically purchase a product-service package rather than pure products. (Kuusisto and Meyer, 2003)

Lately, the nature of innovation processes has become more distributed, and many innovation-driving contributions, such as information and knowledge, come more often from suppliers, buyers and external experts. The balance between internal and external knowledge acquisition and innovative capability is changing compared to traditional manufacturing-related innovations. Service innovations can be characterized as customer-specific solutions which are based on new combinations of existing service activities. They develop incrementally through an informal process focusing on joint problem solving with the customer, which underlines the importance of tacit knowledge. The success of a new service depends often on

the absorptive capacity (Cohen and Levinthal, 1990) of the client as well as the innovative capability of the supplier. The role of end-users in an innovation process is crucial and enables proactive service and technology development (Kuusisto and Meyer, 2003).

With regard to the applicability of the above-mentioned service innovation typologies specifically in KIBS sectors, Nählinder (2005) argues that KIBS firms can carry out technological process innovations, organizational process innovations and service product innovations. First, technological process innovation means that the firm introduces a physical product innovation made in another firm and uses it to enhance the service production process. An example of this would be a new software program which enables a KIBS firm to make a process innovation e.g. in technical design. Organizational process innovations, in turn, refer to new forms of organization of service production. Service product innovations in KIBS firms, on the other hand, can be seen as a source of innovations for their client firms. In her thesis, Nählinder (2005) further notes that when KIBS firms develop service products, they often get ideas from their clients in the process of co-production and may also introduce them to other firms. She therefore emphasizes the role of KIBS firms as agents of innovation transfer between firms. In comparison with this, there are studies which also concentrate on KIBS innovation in their own right. For instance, in his thesis, He (2003) stressed this viewpoint, and by using a survey instrument and data from Singapore KIBS firms he showed e.g. that knowledge interaction with manufacturing clients is positively related to KIBS firms' innovation behavior.

Miles (2003a) makes a distinction between 1) innovation in KIBS and 2) KIBS-related innovation in clients in different KIBS roles. According to his study, the main roles of KIBS in services and innovation are 1) informative, 2) diagnostic, 3) advisory, 4) facilitative, 5) turnkey and 6) managerial roles. In an innovation process, KIBS can act as intermediaries filling the gaps in resources and innovation management capabilities or less directly bridge them. The type of bridging can be:

- expert consulting: particular solutions to particular problems
- experience sharing: transferring lessons-learned from one context to another
- brokering: getting different sources and users in contact across a wide range of services and resources
- diagnosis and problem clarification: articulation and definition of problems or needs in innovation
- benchmarking: identifying good practices through an intermediary
- change agency: developing organization from a neutral outside perspective (den Hertog, 2000)

Miles et al. (1995), who put forward the first definitions of knowledge-intensive business services (KIBS), suggests that KIBS are “private companies or organizations relying heavily on professional knowledge, i.e. knowledge or expertise related to a specific (technical) discipline or (technical) functional domain, and supplying intermediate products and services that are knowledge-based” (Miles et al., 1995; den Hertog, 2000). Toivonen (2004) has defined KIBS in her thesis as follows: “KIBS are business service companies, i.e. private service companies which sell their services on markets and direct their service activities to other companies or to the public sector. They are specialized in knowledge-intensive services, which means that the core of their service is contribution to the knowledge processes of their clients, and which is reflected in the exceptionally high proportion of experts from different scientific branches in their personnel”. Also some criticism has been voiced regarding particular points in these general definitions. For instance, as mentioned by Toivonen (2004),

restricting the definitions to companies (or organizations) only has evoked some criticism. It can thus be suggested that in the present study in addition to KIBS as organizations, they could also be defined as services within an organization, which also provides different types of services or even produces physical goods together with services (“hybrid” organizations).

KIBS organizations can exist in several businesses and industrial branches: For instance, Leiponen (2005, 2006) who analyzed the data from a survey of 167 Finnish KIBS firms, distinguished the studied firms into industrial design, advertising, machine and process engineering, electrical engineering, management consulting and R&D services. On the other hand, Wong and Singh (2004), who studied innovation patterns of KIBS firms in Singapore on the basis of a survey of 180 firms, focused on the four main KIBS sectors; 1) IT and related services, 2) market research, business and management consultancy, 3) architectural, engineering, land surveying, other technical and 4) R&D, advertising, publishing, exhibitions and conferences.

The definitions as such bring forth some of the main characteristics of KIBS. Many of the characteristics described here are typical for most KIBS sectors. Some of the characteristics (e.g. project based business thinking) may be more typical to KIBS operating in the built environment with a strong technological basis of knowledge, e.g. design, engineering and project management service providers (see Gann and Salter, 2003). KIBS can basically be divided into two groups (Miles, 2003b): traditional professional business services and new technology-based KIBS, of which the focus of the present study is on the latter. The recognition of KIBS specific characteristics is essential for the analysis of innovation aspects in these services and in comparisons of them with manufacturing industries. Table 1 below depicts the main characteristics with the referenced literature.

Table 1. Firm and lower level characteristics of KIBS.

<b>Characteristic</b>	<b>References</b>
<b>Knowledge intensity</b> Capability to organize, diffuse and utilize knowledge; especially highly specialized tacit knowledge is crucial for KIBS firms.	Miles, 2003a; Toivonen, 2004; Miles et al., 1995; Leiponen, 2006
<b>Project-based business thinking</b> Typically, many KIBS firms experience the problem of not having enough time or other resources for creativity and innovation, as project metrics are those that matter.	Gann and Salter, 2003; Kässi, 1997; den Hertog, 2000; Blindenbach-Driessen and van den Ende, 2006
<b>The level of R&amp;D efforts is relatively low:</b> KIBS usually innovate by other means than manufacturing companies. Rather than on R&D, the focus in KIBS is on human capital and technology investments.	Miles, 2003b, Gallouj and Weinstein, 1997; Brower, 1997; Howells and Tether, 2004; Leiponen, 2005; Freil, 2006
<b>High level of supplier-user interaction:</b> Customer orientation is strong; also in innovation activities.	Aranda and Molinas-Fernandez, 2002; Nählinder, 2002; Bettencourt et al., 2002; de Brentani, 2001
<b>Staff profile:</b> High portion of highly educated experts employed.	Toivonen, 2004; Leiponen, 2005; Miles, 2003b
<b>Collaboration, learning and renewal capabilities</b> play an important role in companies. The ability to solve customers' problems is crucial.	Baark, 2005; Leiponen, 2005; Tether, 2005
Increased significance of <b>utilization of ICT tools</b> (especially in T-KIBS)	Baark, 2005; Gann and Salter, 2003
<b>Intangibility</b> in services A common service characteristic that can also be seen in KIBS.	de Jong et al., 2003; Vermeulen and van der Aa, 2003
<b>Inseparability</b> in services A common service characteristic that can also be seen in KIBS.	de Jong et al., 2003; Vermeulen and van der Aa, 2003

With regard to innovativeness, the CIS2 research (Eurostat, 2000) suggests that so-called T-KIBS (Technology-KIBS), including e.g. IT related services and technical engineering services, seem to be relatively innovative. On the other hand, some research results (cf. Wong and Singh, 2004; Leiponen, 2001) show that architectural and engineering services are less innovative than many other KIBS sectors.

The long-established growth trend of KIBS can be expected to continue as suggested by Toivonen (2004): “A central reason for the growing service demand is the versatile and up-to-date expertise of KIBS, which is derived from abundant client contacts. Clients’ purchasing know-how is, however, decisive in the success of the service. Besides the quantitative growth, the role of KIBS can be anticipated to strengthen as their services link ever more tightly to clients’ strategies. The service content is also changing in KIBS: client-specific know-how is stressed and the service content is broadened to include packages and comprehensive solutions” (Toivonen, 2004).

Due to their significance in knowledge-intensity and innovations, the present paper focuses on TEC firms. The services, and some characteristics and industry trends affecting the operating environment of these types of firms are presented in the next chapter before a more detailed analysis of service innovations in such companies, based on empirical data from Singapore and earlier data from TECs in Finland.



### **3 TECHNOLOGY AND ENGINEERING CONSULTING SECTOR: SERVICES AND INNOVATIONS**

#### **Knowledge-intensive services provided by technology and engineering consultancies**

Technology and engineering consultancies (TECs) form a sub-sector of KIBS. They produce services which cover a wide range of often specialized and technology-based activities, including e.g. research, technical design, planning, consulting guidance and supervision, and varying aspects of project management. Application fields range from construction of projects related to infrastructure, buildings, and industrial plants to environmental assessment and information systems development (Baark, 2001; Bilderbeek and Brouwer, 2001). Company roles vary from subcontracting to turn key contracts. Technical engineering firms apply existing technical knowledge and knowledge from earlier projects to the design of new processes and/or products according to their clients' requirements at different stages of implementation of investment projects.

International alliances and networks have become more common in the engineering and consulting industry and other KIBS sectors. This results from the fact that engineering consultants, as well as firms in other service industries, have traditionally been dependent on the establishment of local affiliates and the movement of highly qualified people for rendering their services on international markets. Internationalization has, therefore, been very difficult for small firms. However, networking with other firms has offered a way to combine complementary resources and thereby helped to win project contracts on international markets. Co-operation in international networks has also increased as a result of the standardization of rules and procedures at an international level (Baark 1999).

The industry can typically be defined by studying the products and services which the companies operating in the industry produce (e.g. Porter, 1980). Technology consulting and engineering companies provide knowledge, know-how and expertise of their staff to their clients. These services normally involve technical designing, planning and varying aspects of project management. Traditionally, companies in the industry can be divided into two groups. The first group comprises engineering companies that provide traditional engineering services and other professional services of a technical nature. The second group consists of companies planning and implementing investment projects with varying responsibility on behalf of their clients. (Kässi, 1997)

Work in consultancies operating in an established, built environment is typically based on projects and information and knowledge transfers between the suppliers, project companies themselves and their clients (see Figure 3; Gann and Salter, 2003) In order to understand the tasks an engineering company undertakes, the general phases of an investment project – e.g. idea observation, preparation, feasibility studies, decision-making, bidding processes, comparisons, actual conduction and handover to the client - at a client company must be identified (Kässi, 1997).

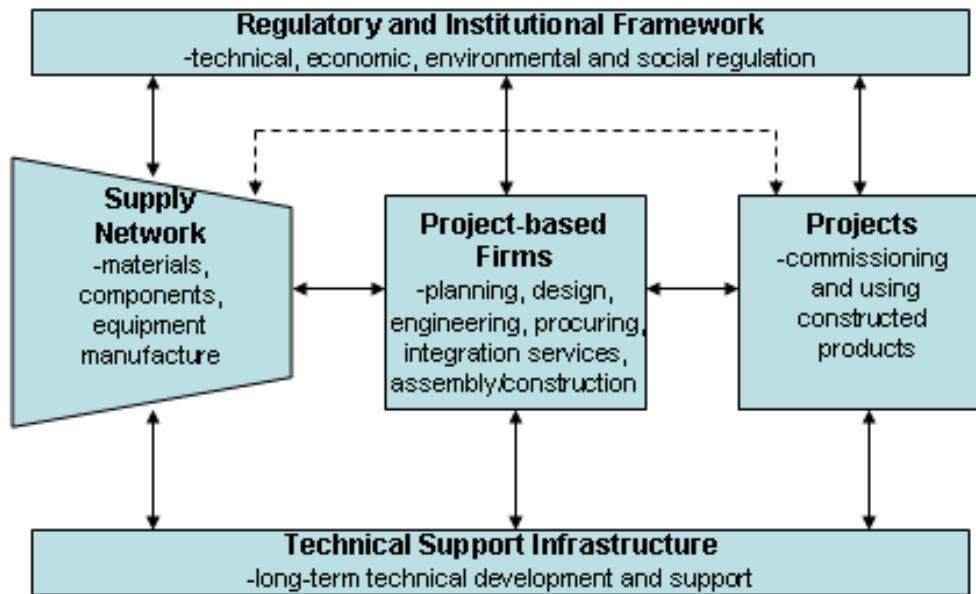


Figure 3. Knowledge and information flows in project-based processes (adapted from Gann and Salter, 2003).

In the case of subcontracting, one main contractor cannot normally supply or manufacture all of the project or the parts of the project alone. Thus, it buys the missing project parts from subcontractors. In partial projects, different suppliers independently market and supply different parts of the main project directly to the buyer, who has the responsibility of coordination and integration. A turn key project of a TEC firm typically involves the delivery of a complete plant, factory or institution. The main contractor is responsible for the marketing, negotiations and set-up of the project, while subcontractors may deliver some parts. The seller has to make the project operational and quite literally hand the key over to the buyer. Completeness is the main characteristic that distinguishes a turn key project from other project types. In these projects, the seller is often either the supplier of a major component of the investment or a major international engineering company. (Cova et. al., 2002)

Different roles and responsibilities of engineering companies in the actual implementation phase can be considered by studying whether the engineering company operates on the seller (contractor) or purchaser (investor) side. The party which takes responsibility for the project as a whole takes care of project management (Kässi, 1997).

In his extensive research on the Finnish engineering industry, Kässi (1997) distinguishes two basic types of engineering companies by studying responsibilities that companies are willing to take in the projects of their clients: 1) engineering design companies, who sell technical planning, their know-how and project services during different stages of implementation of an investment project of a client and who do not take final responsibility for the technical and economical success of the project, and 2) engineering project companies, i.e. organizations which provide complete projects or subprojects on a turn key basis. They bear the risks and

responsibility for the project as a whole, including its technical and economical aspects. After the implementation is completed, the responsibility and risks are transferred to the client.

Typical general criteria that form the competitiveness of engineering design companies are 1) professional staff references, 2) project references of the company, 3) details of the offer and 4) price. Obviously, this stresses the importance of people and their expertise in the business of selling knowledge. Project references imply that the company has a tradition in the industry in question. Engineering project companies offer complete projects or subprojects on a turn-key basis, which affects how competitiveness is assessed. These aspects normally relate to the credibility and suitability of the technological concept, schedules and financing. The weighting of factors always depends on the project at hand. An important task for any engineering company is to assess the competitiveness of its offer and how it can be improved by influencing the factors. (Kässi, 1997; Laaksolahti, 2005)

Recent advancements in ICT technologies enable also smaller companies to participate in international projects that take place far away from their home office, even overseas. These projects were earlier only dominated by a handful of global engineering companies with established local affiliates, but now even local engineering companies can deliver their services electronically and co-operate internationally due to the development of ICT. The diffusion of ICT has also more larger-scale effects on how companies produce their services. (Baark, 1999)

Technical services play a significant role in the value networks of the new economy. While firms focus on their core business activities and outsource the others, the demand for knowledge-intensive business services is increasing. Increased outsourcing is, indeed, a global trend still largely affecting the demand of knowledge intensive and other services (e.g. Viitamo, 2003, Salmi et al., 2004). Technical engineering services are also acquired more and more through turn-key contracts including all kinds of services in the same package. Smaller firms need to network if they wish to compete with larger consultancies. The competencies related to business services are thus crucial for the traditional manufacturing industry and service sectors, as well as for the productivity of new business areas. The amount of different private business services has increased significantly in recent years, and in small open economies such as Singapore or Finland their share in the total economy has grown so that they are now playing a major role in national innovation systems. Knowledge intensive business services are also dynamic in terms of export value numbers, but at the same time services have become more versatile: in addition to technical engineering services, especially ICT services and new management consulting services have multiplied their export in a few years. (Lith, 2002).

Development of engineering and consulting into an industry has, in the long term, been influenced by increased outsourcing of industrial engineering activities. At the same time, the characteristics of the acquired engineering services have changed. Nowadays, industrial companies are transferring more responsibilities to suppliers, which means increasingly larger engineering service entities including not only traditional engineering but also e.g. financial and business managerial expertise. Industry-specific structural changes have also had an influence on the demand of engineering services. For instance, in many traditional industry fields, the engineering services markets do not grow, but their emphasis changes from "Greenfield" projects to smaller but demanding renewal investment projects. Globally, in many industrial fields, also environmental and energy-related services have become more

significant and their demand has increased as the pressure from various sources towards more environmentally friendly production processes has taken place. (Viitamo 2000, 2003).

Internationalization is another characteristic affecting the dynamics of engineering and consulting as an industry. This is seen, for example, in studies focusing on the Finnish technical engineering industry (Salmi et al., 2004). However, this is a global trend influencing how firms transform their business activities from locally-oriented to more global. While the markets of engineering consultancies have become global, typical practical competence areas on which efforts in companies are focused are related to language and multicultural skills, customer service and utilization of information and communication technologies. One of the main challenges in the future is the development of new processes and business models, as sustainable profitability cannot be guaranteed with conventional approaches only (Lith 2002; Viitamo 2000).

Technology-related engineering consultancies have a strong influence on the birth mechanisms and diffusion of new technologies in many industries and, thus, on the national innovation system and competitiveness. First, technical engineering services can transfer knowledge or technology from machinery suppliers or sub-contractors to client firms (Baark 2001, 2002). Additionally, collaborative innovation with customers is often strongly associated with engineering consultancies' projects (den Hertog 2000; Bilderbeek and Brouwer, 2000). It is quite typical for knowledge intensive business services that the entity composed of small changes in collaboration with clients and experts is likely to gradually lead to greater changes. Thus, active interaction between the customer and the service provider is crucial for the birth of new knowledge and innovations.

Even though innovations of technical engineering firms are mainly the result of project collaboration with clients, the firms also naturally have their own internal innovation activities. Internal innovation activities are especially important for the non-technological elements of services. Service innovations can include several dimensions; e.g. in addition to or instead of technological solutions, they can include e.g. a new customer interface, a new service delivery channel or a completely new service concept (see den Hertog, 2000). On the other hand, a new service concept can only mean re-organization of a service or a problem, and then the form of innovation is not as clear as those in products. In these cases, the views of targeted customers and markets serve to assess the real innovativeness of a new service concept. The ability to develop new service concepts by product, process and delivery channel innovations will be a major factor in competitive advantage in the near future.

Systematic competence development and innovation activities are, however, quite difficult for engineering consultancies to conduct because of the more intensive competition and decreased profit margins. Consolidation by mergers and large multinational companies' acquisitions of smaller specialized consultancies as well as the fierce competition are other typical characteristics of industry. The fierce competition in both local and global markets has led especially to the shortening of the average length of projects and a decrease in engineering and consulting efforts. This also limits the possibilities of research and development of engineering services, as the invoicing rates need to be kept at a high level. For long-term business development, the new knowledge-intensive service products might, however, be more useful than services requiring a small amount of customer-specific applications. Ignoring the systematic development of competencies will sooner or later lead to a decrease in the company's value-adding abilities.

In service companies, the activities are more distributed and non-systematically organized than in industrial companies, which often have a separate R&D unit. Therefore, measuring the level of R&D efforts at the service sector remains an additional relevant problem. Furthermore, internal personnel training is often a more significant development investment than R&D in service companies, and it can even replace R&D as a development forum of new products. (Luukkainen and Niininen, 2000).

In the analysis of Finnish engineering consultancies (Salmi et al., 2004), it was found that competition among rival firms and the bargaining power of buyers have the most negative impact on the profitability of engineering companies. These two forces have also had a significant impact on the development of the industry structure, for example, on the recent trend of industry consolidation in engineering consulting firms. Especially larger firms are increasing their size and number by strategic growth and mergers and acquisitions. The incentives behind consolidation include cost reductions and rationalization of operations, but also a need to acquire skilled engineers. Skilled workforce is the most important resource for engineering consultancies since their core competence and competitiveness is based on the ability to apply existing technical knowledge and knowledge from earlier projects to the design of new processes and/or products according to their clients' requirements. The key challenge for engineering consultancies is, therefore, to find the right combination of competencies, to be able to share accumulated knowledge between people, and to make use of modern ICT innovatively.

Internationalization and new customer segments require cooperation and networking with foreign engineering companies. This can be seen as a key opportunity, as well. More efficient knowledge management and new business models (including service 'modularization' and customer orientation) are other important opportunities for engineering consultancies.

The effect of business cycles has been particularly strong on the profitability of engineering firms. This weakness may, however, to a certain extent be overcome by forming networks between firms in different sub-sectors or by broadening the market area (i.e., by acquiring new foreign customers). Much of the so-called bulk design in industrial countries has been shifted to countries with a lower cost level. Another weakness in the engineering consulting business is the lack of resources for research and development. This hinders both service innovations and business process development. In addition, the general image of the sector is nowadays somewhat degraded, and this leads to problems in recruitment. Hence there is a need to improve this image, e.g. by marketing.

As said above, a crucial challenge for engineering consultancy firms is to move to the networked business model, which would provide new opportunities in other market segments or in providing broader service concepts. The network model also enables the development of competencies and strengthens the resource base of a firm. Barriers to the related transition towards the network model include e.g. the lack of resources for overlapping business models, possible problems in customer relationship management and complex business relationships. The success of the networked business model thus depends on participating organizations' understanding of and agreement on the rules of cooperation.

Entry barriers to the engineering industry have traditionally been relatively low. Employees' technical competences and the required demand of services have been the requisite starting point for the establishment of a new company. In addition, there have been no remarkable capital investment requirements. Therefore, the amount of small-sized engineering

consultancies has increased in many regions. One reason for this increase has also been the increase in subcontracting inside the industry. Larger engineering consultancies have lately transformed into main key contractors who use smaller consultancies as project-specific subcontractors. (Lith, 2002). However, even though the entry barriers seem low, the entry in practice requires references from the industry, as it is easier for an existing player to build a trustworthy picture of competencies in project negotiations than it is for a new player in the mature market.

Typical TEC client sectors are health, energy, education, general building, industrial processes, transportation infrastructure, vehicle platforms and systems as well as water (Tidd and Hopkins, 2006).

At present, engineering consultancies provide services for the total life cycle of clients' assets. Examples of these types of services are (Tidd and Hopkins, 2006)

- Asset integrity management
- Commissioning / decommissioning clients' assets
- Conceptual design
- Environmental assessment
- Feasibility studies
- Inspection analysis
- Lifetime studies
- Planning and permitting
- Project development
- Regulatory analysis & development
- Rehabilitation
- Site selection & supervision
- Systems integration
- Testing and inspection

For example Ove Arup, a well-known international engineering consultancy firm, provides planning, design, engineering and project management services for its clients. The firm has put efforts into knowledge management systems, but a survey among the engineers in the firm indicated that in design and problem-solving, discussion with colleagues was rated twice as valuable as knowledge databases, and consequently, engineers were four times more likely to rely on colleagues (Tidd and Hull, 2003). This is due to the significance of tacit knowledge that is difficult to codify, and to the complexity and uniqueness of each project, which limits the re-use of standardized knowledge and experience (Tidd and Hull, 2003). This example brings forth the significance of some of the basic characteristics of the engineering industry, i.e. specified knowledge-intensity and project-oriented business thinking.

Technology consultancies also often operate in a built environment in which the environment itself not always plays such an important role. However, new specialist skills related to both downstream and upstream services, which e.g. engineering and design firms provide, are also needed in today's competitive environment in addition to the technical skills to implement a project. Upstream services can be related to the early stages of project development and financing, and downstream services to facilities and life-cycle operation costs management (Gann and Salter, 2003). The demand for new skills and innovations is driven by the pressures on the supply and demand sides.

With regard to the discussion on the types of service innovations in the previous chapter, we can notify that TECs, the focus group of the present study, are an interesting object of research as they cover a wide range of different types of innovation activities. Categorizations of types of innovation in TECs are particularly rare in previous research, but e.g. Tidd and Hopkins (2006) have recognized the following types in their qualitative research on four case organizations from the technology and engineering consultancy field: a) new business models, b) internal processes, c) techniques/platforms, d) products/widgets, e) project partnering, f) design features, and g) solution extensions. Some of these modes, such as d, e, f and g, are especially project-based. However, there are many variations in these modes depending on the case and the client. Also, Tidd and Hopkins (2006) argue that some of the most important innovative work undertaken by TECs is in partnership with well-informed and experienced clients. Therefore, there is a need to emphasize the recognition of the lead user clients (Tidd and Hopkins, 2006) and to see the client as an active participant in the service creation process, especially in the complex service environment (Mills and Morris, 1986).

### **Structure of industry and markets of TECs globally and in the Singapore region**

On a global scale, both production and services are moving eastwards (STD, 2005). Larger firms in the consultancy sector have focused their attention on the new fast-growing economies in Eastern Europe, Russia and Asia. The following table depicts the world's largest firms in engineering and architectural fields. The internationalization of companies in recent years has also included plenty of mergers and acquisitions. Consolidation in the industry is likely to continue as a major trend. As seen in Table 2, the largest consultancies are very large and nine of the world's ten largest firms in the industry are considered multi-disciplinary organizations.

At the same time, we have to remember the other extreme: most of the firms in the business are very small in size. Indeed, the engineering industry typically has a very polarized structure in terms of turnover and firm size. Firstly, in terms of the number of firms, SMEs dominate – for example in Europe over 90% of firms employ less than ten persons (see e.g. EFCA, [www.efcanet.org](http://www.efcanet.org)). The situation is the same elsewhere: In Singapore, over 90% of firms listed in ACES (Association of Consulting Engineers in Singapore) web sites employ less than six persons (ACES, 2006). Secondly, a relatively small number of firms account for a very substantial part of sector turnover. These larger firms usually operate on a predominantly international market and the delivery of engineering consultancy services in global markets has, in fact, been dominated by a small group of firms located in Europe and the US (Baark 1999).

Traditionally, as other service industries, engineering consultancies have been dependent on recruiting highly qualified personnel and on the establishment of local affiliates for rendering their services in overseas markets. According to Baark (1999), however, the recent development of ICT has significantly influenced the patterns of production and delivery of engineering services.

Table 2. The World's top 10 consulting engineering and architectural groups (STD, 2006).

<b>Group</b>	<b>Country</b>	<b>Employees</b>	<b>Turnover MUSD</b>
URS Corporation	USA	29200	3918
AECOM	USA	24000	2400
Altran Technologies	France	16290	1785
CH2M Hill Companies, Inc.	USA	14500	3152
WS Atkins, plc	England	14300	2517
SNC-Lavalin Group	Canada	11940	3132
Parsons Corporation	USA	10312	3000
Parsons Brinckerhoff	USA	9600	1448
Arcadis Group	Netherlands	9208	1241
Mott MacDonald Group	England	8141	918

As for the size of TEC companies, small firms are mainly operating in niche areas and have a limited focus in terms of activity type and disciplinary domain. Their business is thus based on specialized knowledge and expertise. Large firms, on the other hand, usually have a wider range of services. For example, in their analysis of the Dutch engineering industry, Bilderbeek and Brouwer (2000) found that most of the top-10 firms operate with a so-called one-stop shopping formula, offering the whole assortment of engineering activities. However, relatively few firms can actually operate with reasonable competitive strength in the whole range of activities and disciplines.

This section focuses on the structure of the services and engineering industry especially in Singapore, which is a very unique country with its mix of state planning and capitalism. Since its independence in 1965, the Singapore has gone through a transformation from a third world country to one of the most competitive countries in the world<sup>3</sup> (WEF, 2006). Initially, its growth was based on labour-intensity and developing skills, and later on capital-intensive industries. The country's traditional three industry pillars have long been electronics, precision engineering and chemicals (Parayil, 2005). Capital-intensity has then led to technology-intensity and knowledge-intensity in e.g. the ICT sector and to the development of new products in manufacturing industries. Singapore's R&D efforts have also increased remarkably in recent years. In 2005, the total R&D expenditure was 4582 million Singapore dollars, which was of 2.36% of the gross domestic product (GDP) (Agency for Science, Technology and Research, 2006).

However, in addition to efforts in traditional manufacturing and newer industries such as biotechnology, the service sectors in Singapore have long played a significant role in the economy, and many services have increased remarkably in recent years. Transportation, logistics, telecom and tourism services have been the most important service branches for a

<sup>3</sup> In the year 2006, Singapore was ranked fifth in the World Economic Forum's competitiveness report, while Switzerland was the most competitive country followed by Finland and Sweden.



long time. In the knowledge era, however, the relative significance of different knowledge intensive business services such as ICT, legal and financial services as well as architectural, technical engineering and consulting services has also increased. This implies at the country-level that there has been a transformation from technology- to knowledge-intensiveness. Knowledge-intensive services accounted for a 27 per cent share of the Singapore GDP in 1983 and a 35 per cent share in 1997 (Wong and Singh, 2004). Especially the increase in IT services has been an important factor in the growth.

As in many countries all over the globe, the service sector has, in recent years, become more dominant in the overall market in Singapore also. A wide variety of different types of services exists within the service sector. Table 3 below depicts the increase in the total service sector in recent years. In 2003, the share of services of the GDP was 64%, and that of employment 69% (Singapore Department of Statistics, 2005).

Table 3. GDP by Industry in millions of Singapore dollars (Singapore Department of Statistics, 2005).

<b>Industry</b>	2002	2003	2004	2005
<b>Good-Producing</b>	48 741.3	48 566.4	57 765.1	62 207.1
<b>Service</b>	103 100.1	104 159.0	113 395.4	121 901.1

As a whole, the service sector comprises the following main service branches (Singapore Department of Statistics, 2005):

- Wholesale and Retail Trade
- Accommodation and Food & Beverage Services
- Transportation and Communication
- Financial and Insurance Services
- Real Estate and Business Services
- Community, Social and Personal Services

In terms of number of employees, Wholesale and Retail Trade is the most important one with more than a 31% share of the total workforce in the service sector, followed by Real Estate and Business Services, to which the main focus group of the present study, TECs, belong. With regard to the Singapore Standard Industrial Classifications, the focus in our present study is on the SSIC 741 and 742 groups, i.e. Architectural and Engineering Activities (741) as well as Industrial Design, Technical Testing and Analysis Services (742). In the whole group of architectural, engineering and technical services, there were 2770 establishments with some 25600 workers in Singapore in 2001 (Singapore Department of Statistics, 2005). Of these, 903 establishments could be categorized as “engineering services”, while the rest belong to “architectural services” (632), “industrial design” (52) or “other related services” (1183).

When studying the clientele of the largest engineering consultancies on the basis of the public information found e.g. in company reports and on company web sites, it can be observed that the TECs in Singapore have both public and private clients. Not surprisingly, the focus of the consulting services is on the industries that have a strong position in the Singapore region, e.g.

construction, chemical process industries, manufacturing industries such as the electronics industry, as well as recently emerged industries such as biotechnology, water treatment, energy and the environment. However, not many of the larger consultancies are Singapore-based. Instead, several of the world's largest multi-national engineering consultancies, such as the URS Corporation, AECOM, CH2M Hill, Parsons Brinckerhoff, Black & Veatch, Arup and Pöyry, have an office in Singapore. On the other hand, for some large companies the Singapore office is mainly representative by nature because of Singapore's advanced infrastructure and good strategic location for traveling to other Asian locations. The largest companies typically provide multi-disciplinary services, and in addition to traditional technology and engineering consulting, also management and financial consulting are often complimentary service areas for these firms. The largest Singapore-based TEC company also providing multi-disciplinary services is CPG Consultants, which with ca. 2000 employees holds the 65<sup>th</sup> position on the list of the world's largest architectural and engineering consultancies (STD, 2006).

Singapore's solid infrastructure and extensive global connectivity make Singapore an attractive location for offices of several multinational service companies. Therefore, more than half of the world's top 40 engineering design firms have established headquarters, manufacturing and R&D operations there. Singapore is also home to the significant operations of 9 of the top 10 global process control and instrumentation companies. As a result, many of Asia's infrastructural and industrial projects have found their engineering solutions in this hub of technological engineering excellence.

In addition to traditional expertise areas in construction and process industry engineering, the environmental technology sector, in particular, is enjoying strong growth in Asia. To meet the national environmental sustainability needs and to promote this vibrant industry, Singapore aims to become a Global Hydrohub, accounting for 3–5% of the global water industry by 2018. In addition, Singapore is striving to become a leading provider and sophisticated user of alternative energy products and services.<sup>4</sup>

For the TECs, from the external industry analysis, it can be said that also in the case of Singapore, the competition between companies in the industry as well as the bargaining power of clients (which is partly caused by the intense competition) are significant forces influencing the competitive situation of TECs in Singapore. As said, Singapore has been a relatively tempting option for foreign investments, and its strategic location is attractive to multi-national companies who may operate the Asian market from Singapore, which increases competition also in the consultancy services sector. Therefore, locally and in some sub-areas of engineering and consulting, the threat of new entrants to the industry plays a significant role. The relative strengths of the forces of new entrants, substitute products and services and suppliers vary across the industries for which a TEC mainly provides solutions. For instance, in process industries many equipment suppliers nowadays also have engineering services, and a consultancy that may have previously been responsible of a large project may now work with a minor part in a project led by an equipment supplier. All significant forces have to be taken into account in the development of profitable strategies and new business models. A global phenomenon, consolidation, can also be seen in South-East Asia, as large multi-national companies acquire smaller, specialized local companies when specialized knowledge is needed. On the other hand, Singaporean consultancies have in recent years exported their know-how abroad, especially in construction projects to the Middle East.

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<sup>4</sup> See e.g. [http://www.sedb.com/edb/sg/en\\_uk/index/industry\\_sectors/engineering\\_and\\_environmental.html](http://www.sedb.com/edb/sg/en_uk/index/industry_sectors/engineering_and_environmental.html)

From the internal analysis point of view, the expertise and knowledge base of the individuals in TEC firms are the company's most significant resources. It can be assumed that for sectors such as biotechnology in Singapore, it may be easier to recruit talented (especially young) work force than for other, more traditional sectors such as construction engineering. The competitive edge is also dependent on companies' ability to integrate, disseminate and utilize the knowledge of individuals for collective access. Both explicit and tacit knowledge are important for innovations (Leiponen, 2006) and the transfer of knowledge from more experienced employees to younger engineers should also happen effectively in order to assure a high-level knowledge base in the company.

ICT has also changed the working methods of several consultancies in past decades (Baark, 2001). Still, ICT is more an enabling factor, while individual knowledge is of the most value. At the organizational level, ICT has changed the routines of work and enhanced productivity. Companies have also been able to produce some innovative solutions and developed new tools with the help of ICT. On the other hand, consultancies are often dependent on the software and ICT tools that are used by their clients and other collaboration partners. Singapore is a local centre of knowledge and ICT expertise, but consultancies operating e.g. in other South-East Asian countries may not always get access to as solid an ICT infrastructure as the one in Singapore.

### **Quest for innovation in TECs**

Even though research on service innovation and KIBS has emerged in past decades, not much has been written yet on innovation especially related to TECs. Special types of characteristics of industry such as project-based business thinking, close supplier-client relationships and lately also increased significance of ICT use (see e.g. Gann and Salter, 2003) have an influence on innovation in the sector. Earlier literature has also focused more on a higher level analysis of KIBS' influence on innovation in their client industry or some particular region. Relatively little has been written about the innovations and knowledge management in TECs themselves, and how these firms may be innovative on their own.

As mentioned before, studies on TECs and innovations in South-East Asia are also relatively rare. As one example of studies on this topic in Asia, Baark (2005) studied engineering consultancies in Hong Kong. He recognized three main dimensions influencing the accumulation of knowledge for innovative behavior in firms: the role of mobilizing creative human resources, the role of partnerships and interaction in project-based organizations and effects of widespread use of ICT for enhancing knowledge flows and innovation. In his empirical studies in Hong Kong (Baark, 2005), he also found intrinsic and extrinsic barriers influencing the transition of moving towards an innovation-oriented mode of learning. Extrinsic barriers are partly dependent on the particular geographic area in which the study was done, but some of them – such as lack of (inter-)organizational routines for networking and using ICT effectively – and most of the intrinsic barriers such as strong emphasis on traditional approaches for exploiting existing knowledge instead of exploring new, can be assumed to be typical for engineering consultancies in other regions, as well, as shown in our previous study on the transformation to collaborative innovation in Finnish technology and engineering consultancies (Ojanen and Hallikas, 2007).

There is a practical need for innovation in TEC companies, as also discussed in earlier studies. A lack of resources and conventional approaches to work seem to be typical barriers to exploration and radical innovations (e.g. Baark, 2005; Ojanen and Hallikas, 2007). The working environment for TECs is often strongly project-based and client-led, and often, clients do not expect radical innovations to happen during the projects. However, in many industries, clients can be seen as lead users who also assess the ability of a TEC to provide innovative solutions, in addition to implementing their projects cost-effectively and on schedule.

Moreover, innovation in technology and engineering consultancies has concentrated on management of knowledge and organizational learning (e.g. Sverlinger, 2000, Aranda and Molina-Fernandez, 2002; Baark, 2005). This is quite obvious, as the competitive edge in the sector is strongly based on technical knowledge: how to acquire, transfer and use it to commercial ends as well as how to reuse the knowledge that is accumulated in previous projects. Technical consultants even see themselves as having an important intermediating role in transferring knowledge in the industry. This sets demands for knowledge management within the organization as well as with external organizations (Sverlinger, 2000). The empirical part of the present study also focuses on the knowledge management perspective, i.e. knowledge acquisition, transfer and utilization mechanisms and their effects on the innovative capacity of TECs.

#### **4 EMPIRICAL RESEARCH ON CHALLENGES AND POSSIBILITIES IN THE DEVELOPMENT OF INNOVATION ACTIVITIES IN TEC SERVICES**

This study has followed a procedure including, first, literature reviews on relevant areas and empirical studies, interviews and exploratory case studies conducted in Finland in 2004-2005 as a background for achieving a sufficient level of understanding. In 2006, exploratory case interviews in Singapore were conducted after establishing a collaborative research project on the issue and focusing the topic on studying how different types of innovations take place in TEC firms and the main enablers of and barriers to innovation in TECs. At the same time, a questionnaire was developed for further study on innovation and knowledge management activities, and the survey was then conducted as a final year research project (Tan, 2007) at the National University of Singapore (NUS), Department of Industrial and Systems Engineering.

The data utilized in the present study firstly includes literature reviews on both innovations in services and services innovation. Particular attention was paid to searching for publicly available material on the industry. The characteristics of the industry were identified from the previous literature as well as from trustworthy public sources, e.g. government and engineering associations' web sites, which increased our understanding of the special concerns and structures of the industry especially in Singapore. In Singapore, the public data was complemented with interviews conducted at TEC organizations as well as at research institutes. The qualitative interviews were exploratory by nature and they were also analyzed together with the previous data of ca. 20 interviews in four Finnish organizations. As a result of the analysis of exploratory cases and literature reviews, the survey on Singaporean TECs focused on knowledge management issues as antecedents of innovation capacity in firms.

##### **Exploratory case research: driving forces, enablers and barriers, and types of innovation in TECs**

Some common influencing forces and different types of service innovation could be found from the qualitative interviews carried out in Singapore. Before the interviews, publicly available material from trustworthy sources, e.g. from the Association of Consulting Engineers Singapore (ACES) and the Institute of Engineers in Singapore (IES), was gathered and preliminarily analyzed in order to become familiar with the special characteristics of the industry especially in the studied region. In the first phase, the plan was to conduct interviews in four large TEC organizations operating in different industries and having different multi-national backgrounds (one company originates from the UK, one from the USA, one from Australia and one from Finland). However, in one of the organizations the data only included company documents and other material and a preliminary meeting, and thus, did not comprise all the topics included in the semi-structured interviews of five director-level persons in the three other organizations. However, the scarce qualitative data was complemented with informal interviews and discussions at research institutes, e.g. NUS, and later analyzed together with the Finnish qualitative data of TECs. Being inherently exploratory, the case studies and qualitative data is thus adequate for the purposes of this study and also provides increased understanding of the research topic and a focus for further, more detailed quantitative studies.

Exploratory case studies were conducted to understand service innovation and knowledge management processes in KIBS firms – in this case, TEC firms. The purpose of these case studies was to increase understanding of our research area, to reconfirm the relevance of the research area from an industry perspective, as well as to confirm some of the findings from the literature review and serve as a complementary resource for more detailed further studies.

In each studied company, a series of semi-structured face-to-face interviews were conducted. Each interview took approximately from one and a half to over two hours, and they were tape recorded. The questions were related to the service innovation types in the companies, their competitive advantage in the industry, their service innovation process, and sources of knowledge for service innovation. Enablers of and barriers to service innovation were also included in the questions.

There is relatively little previous research on the detailed aspects related to innovation within this particular sector, especially in South-East Asia. In addition, the sector is inherently very knowledge-intensive and service innovation plays a significant role within the sector, which are also the main reasons to choose this sub-sector of KIBS as the main focus of the study. The companies could be described as 1) a leading independent consulting and technology group in the processing industry (refining, petrochemical, pharmaceutical), 2) global technical and business consulting focusing on the energy, forest industry, and infrastructure and environment sectors, and 3) technical consulting in the construction industry. In addition to interviews, other data was gathered from newsletters, project profiles, annual reports, brochures, technical papers, client magazines and company web sites.

The interviewed companies were very interested in the topic because they clearly indicated in the interviews that their competitive advantage originates strongly from innovation. The companies want to be more innovative to retain or even increase their competitive advantage. All of them can distinguish their service innovation into product, process, and organizational innovation, which is to some extent consistent with the research conducted by Evangelista and Sirilli (1998), who found that the majority of the companies can distinguish product and process innovation in services.

Two of the interviewed companies have a standard service innovation process, which is similar to the process identified in previous studies (e.g. Scheuing and Johnson, 1989; Johne and Storey, 1998; Gruner and Homburg, 2000; Kelly and Storey, 2000; Alam, 2002). In particular, the service innovation process in the interviewed technical consulting firms similar to engineering design problem-solving process evolves through a series of iterative and overlapping phases: from problem identification, through development of different conceptual solutions, to designing a favored solution and working out details of the physical artifact (Hacker, 1997).

Knowledge is the key in an engineering consulting company. In addition to the knowledge within the company, external sources of knowledge for service innovation are pointed out in the interviews. All of the interviewed companies mentioned clients and suppliers, one of them mentioned competitors, and one of them mentioned universities and research institutes; all these are in line with the literature (OECD, 1999). Below are some of the interviewees' comments in relation to the sources of knowledge and innovation.

*“Our best innovation comes from our work with clients. These days, we increasingly have to bring suppliers in to complement the knowledge that we do not have.”*

*“We serve very conservative companies. They rely on existing technologies. New knowledge and innovation comes especially from equipment suppliers.”*

*“Normally, we have some kind of partnership with academics here, such as NTU and NUS, sometimes on very specific topics to which there is no known solution.”*

Two of our interviewed companies identify seminars and different forums as their external source of knowledge for service innovation. This is consistent with Klevorick et al. (1995), who found that firms access sources of information through industrial fairs, exhibitions, and professional conferences. With regard to ways of acquiring external knowledge, collaboration, partnerships, alliances, acquisitions, and joint ventures were mentioned in the interviews; some examples of that are presented below.

*“Mature organizations’ concern is the human behavior side of the business. We acquired Company X, which has professional expertise in human resource management, to expand our knowledge. We have to be in alliance with the clients.”*

*“We collaborate with competitors. We take over companies specialized in a wide range of services. In China, we have a joint venture with a design institute so that both traditional and new knowledge can be used. ”*

*“When we encounter a very challenging/difficult problem, there are two ways to solve it: one is cooperation with university institutions, another is cooperation with suppliers. We decide on the partnership with the academic staff in the institution or manufacturers.”*

As previously mentioned, according to literature, usually there are no separate R&D functions in KIBS firms (Miles, 2003b; Leiponen, 2006). This was also the case in two of our case organizations. However, one of the interviewed companies has both an R&D center and an R&D institute. After checking the background information for this company, we found that the existence of the R&D center/institute was mainly due to the special industry in which it was operating. The highly specialized and traditional nature of this industry makes it difficult for a leading company to access information externally. To some extent, it implies that in different industries, the relative importance of external knowledge on innovation should be different.

Preliminary findings from these exploratory case studies are summarized in Table 4 below. The types of innovation here are examples, and they can be categorized e.g. into product, process and organizational innovations, but for some innovations the categorization is not so evident. A total of nearly 30 different types of service innovations with different degrees of novelty could be recognized in the interviews in three organizations. Some of the innovations were also related to client interfaces and to the service delivery process, and many of them included several service innovation dimensions, which were earlier mentioned in den Hertog’s (2000) framework.

Most of the findings in our exploratory case studies are consistent with the findings in the existing literature, such as the service innovation types, process, and sources of knowledge for service innovation. Sources of external knowledge are significant for TEC organizations, but as shown in the interviews, a KIBS firm can also have its own R&D center due to the knowledge specificity or the nature of the industry.

Table 4. Preliminary findings from exploratory case studies.

	<b>Company A</b>	<b>Company B</b>	<b>Company C</b>
<b>SI provided</b>	Product—simulation model/package, improvements on client interface for software; Process—combining delivery phases Organization—joint venture, move to different industry, new type of contract with clients, alliance with clients and suppliers	Product—new IT tools, new ranges of service; Process—new ways to deliver service (use mobile phone for installation registrations) Organization—establishment of design institute collaboration	Product—N/A Process—quick deliveries Organization—doing business in other countries, acquisitions, acquiring expertise
<b>SI process</b>	Determination of objective, setting target, idea generation, idea development and revision, implementation	N/A in the interview information	Idea generation, idea development and validation, implementation, launch, test
<b>External knowledge source</b>	Own insight into the market force, clients, suppliers, relevant forums	Clients, suppliers, competitors, market trend, technology trends	Client, supplier, research institute/universities, relevant seminars
<b>Competitive advantage</b>	Capital excellence, technical excellence, HRM excellence	Technical competence (special knowledge and experience)	Technical advancement, innovative solutions
<b>R&amp;D</b>	No R&D department, use of cross-functional geographic team to deal with each project	Has own R&D center, R&D institute	No R&D department, team rotation for challenging projects

The main enablers of and barriers to service innovation were also gathered in the interview data. The forces can be categorized e.g. into strategic and structural forces, organizational forces, communicational forces, technological forces and external forces. Of the observed driving forces of service innovation in TEC companies, similar ones to our previous research in Finnish TECs were e.g. *a wide technological knowledge-base and experience, trust at an individual level, use of cross-disciplinary forums for knowledge exchange and a strong emphasis on real world problems and customer needs as a basis for innovations*. On the other hand, similar types of barriers to innovation in both Singaporean and Finnish data were a *lack of resources* (time and money), as well as *customers' main need for reliable solutions rather than great innovations and internally conventional routines to carry out the engineering and consulting work*.

The results from exploratory cases also showed the variety of origins of innovations and reconfirmed the observation that innovation in TECs often happens as a co-innovation with the client, supplier or another partner or even competitor. These observations from interviews together with TEC characteristics also emphasize the need for more detailed study of knowledge-processing activities, such as acquisition, dissemination and utilization of knowledge, and their influence on service innovations.



## **A survey on innovation management of TECs in Singapore**

The quantitative phase of the TEC study, reported in more detail by Tan (2007), focused on exploring the relationship between knowledge acquisition, dissemination and utilization with the innovativeness of TEC firms<sup>5</sup>. Another target was to explore how environmental dynamism, the specialization of the firms and the tangibility of the firms' deliverables could affect the importance of the three dimensions of absorptive capacity (knowledge acquisition, dissemination, utilization) on the innovativeness of TEC firms.

According to the original definition of Cohen and Levinthal, (1990) absorptive capacity was defined as the ability of an organization to recognize the value of new, external information, assimilate it, and apply it to commercial ends. According to Jantunen (2005), who has studied the effect of knowledge processing capabilities on innovation performance in Finnish firms, earlier research on absorptive capacity has used proxies such as R&D intensity to measure the utilization of external knowledge, and has focused on static or accumulated features of this construct. However, some studies (Zahra and George, 2002; van den Bosch et al., 2003) have also focused on temporal aspects, such as how to sustain absorptive capacity in a changing environment. From this viewpoint, in a highly dynamic environment not only the knowledge stock but also knowledge flows are crucial for innovative performance (Jantunen, 2005).

Instead of innovation performance, this study measured the innovativeness of a firm by the number of innovations the firm has implemented in the past three years. Innovations can be categorized into four main types: product, process, marketing and organization innovation. (OECD, 2005). This approach allows us to capture not only the direct effects of a firm's innovations on turnover, but also indirect effects of innovations. Moreover, as the case studies show, many TEC firms co-innovate with their clients, and if only innovative performance were studied, we would not be able to capture that type innovation in TEC firms.

Table 5 below shows the constructs and measures of the hypotheses used in the study. The questionnaire included several questions for measuring each variable.

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<sup>5</sup> The survey itself, its background, hypotheses, variables, methodological aspects, tests, results as well as conclusions are presented in more detail in the thesis of Tan (2007).

Table 5. Constructs and measures (Tan, 2007).

Construct	Measure	Sources
Dependent Variables		
Innovativeness	The number of innovations developed by the firm over the past 3 years.	Organization for Economic Co-operation and Development (OECD) Oslo Manual - Guidelines for Collecting and Interpreting Innovation Data (2005), Tidd and Hopkins (2006)
Independent Variables		
Knowledge Acquisition	Amount of activities in the firm related to information collection from within and outside the firm.	Cohen and Levinthal (1990), Jantunen (2005), Kuusisto and Meyer (2003), Vermeulen and Barkema (2001)
Knowledge Dissemination	Amount of activities in the firm related to codification and transfer of knowledge within the firm.	Cohen and Levinthal (1990), Jantunen (2005), Nonaka and Takeuchi (1995)
Knowledge Utilization	Amount of activities in the firm related to the effective exploitation of acquired knowledge in the form of new, improved products and services.	Cohen and Levinthal (1990), Jantunen (2005)
Moderator Variables		
Degree of specialization	Inverse of the variety of services provided; inverse of dominant functional diversity.	Bunderson and Sutcliffe (2002)
Tangibility of deliverables	Proportion of projects in the past 3 years where the firm delivered an intangible deliverable to the client.	New scale
Environmental dynamism	Degree of volatility of the firm's business environment in terms of speed of customers' preferences, technical know-how and technological changes.	Jantunen (2005)

The results from the literature reviews in the field as well as from the exploratory case studies led us to state the following hypotheses (Tan, 2007):

- H1: Knowledge acquisition is positively related to the innovativeness of a TEC firm.
- H2: Knowledge dissemination is positively related to the innovativeness of a TEC firm.
- H3: Knowledge utilization is positively related to the innovativeness of a TEC firm.
- H4a: The more dynamic the environment, the more important is knowledge acquisition for improving the innovativeness of a TEC firm.

H4b: The more dynamic the environment, the more important is knowledge dissemination for improving the innovativeness of a TEC firm.

H4c: The more dynamic the environment, the more important is knowledge utilization for improving the innovativeness of a TEC firm.

H5: The more specialized a firm is, the less important is knowledge dissemination for improving the innovativeness of a TEC firm<sup>6</sup>.

H6: The more intangible the deliverables of a TEC firm, the less important is knowledge dissemination for improving the innovativeness of a TEC firm<sup>7</sup>.

The model summarizing the hypotheses is depicted in Figure 4 below:

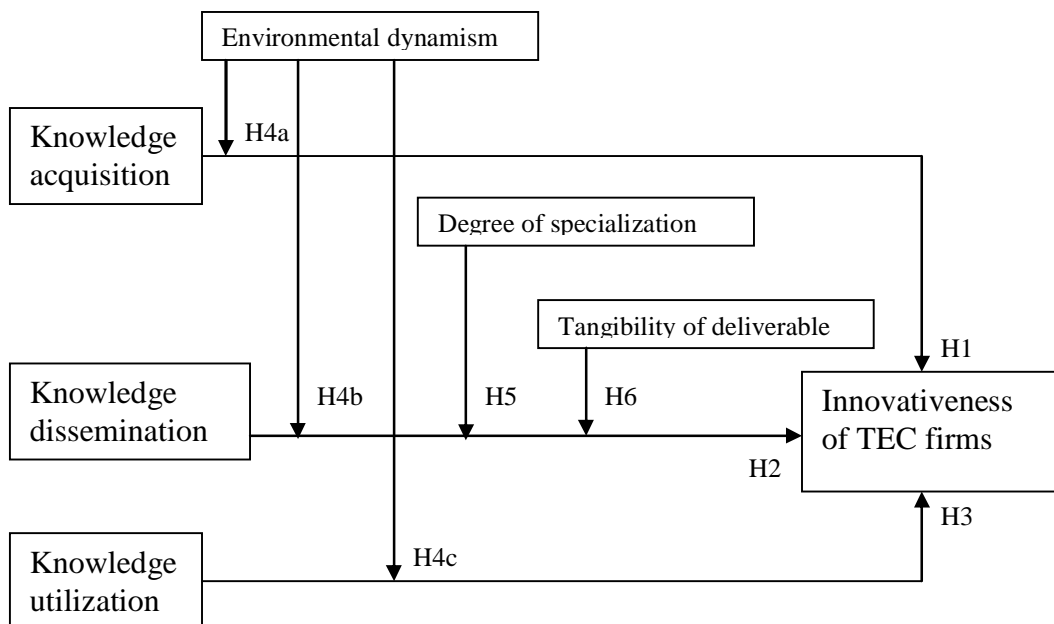


Figure 4. Model of the quantitative study (Tan, 2007).

The survey was conducted among 446 technology and engineering consultancies in Singapore. The population had been consolidated from four main sources: The Association of Consulting Engineers Singapore, The Institution of Engineers Singapore, the Yellow Pages and the Green Book. The survey was focused on the higher managerial staff familiar with research and development. Out of 446 TECs targeted in Singapore, 52 were returned. Even though the response rate was 12.6%, the amount of useable data was only 32 responses (8%

<sup>6</sup> In this study, the degree of specialization of a TEC firm is measured using the inverse of dominant functional diversity (Bunderson and Sutcliffe, 2002); a specialized firm mainly consists of employees in the same area of practice. As stated by Tidd and Hopkins (2006), there is strong informal sharing of knowledge within communities of practice, even across national boundaries, but little sharing across communities even when based in the same location. Thus, formal measures to aid knowledge sharing in more specialized TEC firms might not be necessary.

<sup>7</sup> The knowledge associated with intangible deliverables is usually more context specific (more tacit) for TEC firms as compared to that of tangible deliverables. When knowledge is tacit, proximity and interpersonal interaction are often necessary for its transmission (Szulanski, 1996). Mechanisms for the transfer of tacit knowledge include e.g. mentorship, apprenticeship and repeated practice over a period of time (e.g. Nonaka and Takeuchi, 1995). Therefore, formal channels for effective sharing of tacit knowledge which is usually associated with intangible deliverables may be less important.

of the total population surveyed). This is because this study focuses on firms that innovate, and most of the non-useable data consisted of firms that do not innovate.

As regards the results of the survey, out of the three main stages, only *knowledge acquisition was found to be positively related to the innovativeness of TECs*. This is consistent with our expectation that TEC firms need to constantly obtain new knowledge to keep themselves updated with their clients, who are often intelligent lead users in the market. This can also be explained by the finding of Tidd and Hopkins (2006) that innovations among TEC firms often involve the reuse of established models and plans with modifications rather than designing from first principles. There is a need to keep costs low due to the increasing trend of clients wanting to pass the risks to TEC firms, along with changes in the legal environment that facilitate such a phenomenon. This in turn suggests the need for TEC firms to have a large portfolio of existing plans that cover a wide range of potential client projects. Therefore, the ability to acquire new knowledge especially in the form of existing solutions has a positive correlation with innovativeness.

This analysis may also partly explain why knowledge utilization did not have a significant relation with innovativeness; the application of knowledge to designing new improved products/services from first principles is less preferred since the re-usage of existing solutions is more cost effective. On the other hand, no significant relations between knowledge dissemination and innovativeness were found, either. This could be attributed to the fact that a bulk of the firms that responded were small in size, 70% of them having 10 or fewer consultants. Thus, knowledge dissemination in such firms did not require the set up of formal channels for sharing (Tan, 2007).

The results also show that for TEC firms operating in more volatile environments, knowledge acquisition became more important for their innovativeness. This is consistent with our expectations that firms need to be able to acquire knowledge effectively, especially in rapidly changing environments where knowledge becomes obsolete very quickly, in order to be innovative.

The effects of the degree of specialization of the firm and the tangibility of the firm's deliverables on knowledge dissemination were not so clear. The results in Tan's (2007) survey showed that the relationships of the two moderator variables with knowledge dissemination were consistent with what we predicted. However, these relationships were not significant. This could be due to the fact that most of the firms that responded were small in size and thus were mostly highly specialized, and as discussed above, do not require formal channels for the sharing of knowledge.

Some preliminary conclusions were drawn from the research results: the findings of this research imply that firms striving to be innovative can benefit a great deal from the development of their knowledge acquisition capabilities. These can include taking note of the "best practices" of their employees (OECD, 2005) and collaboration with the firm's clients, suppliers, competitors, research institutes, universities, etc. (Kuusisto and Meyer, 2003).

The extent to which companies should develop their knowledge acquisition capabilities depends on numerous factors. Generally, firms should establish clear channels of communication with their clients and other firms in the industry so that they can keep track of the changes in their clients' preferences and also of the relevance of their technical know-how as benchmarked against other firms.

The survey also had several limitations: it did not consider how the size of a firm might affect the relationships, primarily because we have a relatively small sample size and the bulk of them were small sized firms, and thus there was no basis for comparison. Some interesting results may lie in the fact that larger firms have more resources and thus a higher incidence of engaging in radical innovations. In this case, knowledge utilization may become an important factor in innovativeness on top of knowledge acquisition. Furthermore, the lack of respondent firms which are large in size also resulted in us being unable to study the effect of the degree of specialization of a firm on knowledge processing capabilities and innovativeness.

Secondly, the small size of the firms that responded also impeded us from being able to study how knowledge dissemination can affect innovativeness as most small firms typically do not require formal channels for knowledge sharing. A deeper analysis focusing on large TEC firms could probably provide new insights into the impact of knowledge dissemination on innovativeness. Studying that impact would require the development of adequate measures for informal knowledge sharing, which can be difficult since such forms of sharing are usually highly intangible.

Thirdly, the analysis in Tan's (2007) dissertation suggested that a negative relationship exists between knowledge dissemination and the innovativeness of TEC firms. Although the relationship is not significant here, this could suggest that the presence of formal channels to codify and disseminate knowledge can result in TEC firms having a tendency to reuse suitable existing solutions as opposed to innovating, especially when there is a need for a fast time to market. Thus, a future study on the negative impact of knowledge dissemination on the innovativeness of TEC firms may also provide some new insights.

Lastly, further studies should be conducted to find out what kind of knowledge acquisition capabilities TEC firms need and how they should develop them to enhance their competitive advantage. It is also probable that TEC firms that differ in size or in terms of the kinds of services they provide need different kinds of knowledge acquisition capabilities. Also, deeper study of the impact of various internal and external knowledge sources on service innovation in knowledge-intensive firms would contribute to the research field.

## 5 CONCLUSIONS

The main aim of this study was to generate new knowledge in the fragmented research field of service innovation management by recognizing the different types of innovations in technology and engineering consulting services and some of the enablers of and barriers to innovation capacity in the field, especially from the knowledge management perspective. The study also aimed to clarify some of the existing routines and new constructions needed for enhancing service innovation and knowledge processing activities in the KIBS companies of the TEC sector. Literature reviews, qualitative research with various data sources as well as complementing quantitative research has been utilized in the overall analyses of this research.

Generally, innovation is crucial for the competitive edge of technology-related KIBS firms. Case studies conducted in Singapore support this argument by providing fresh knowledge on several types of innovations in TEC firms. Singapore is known as a South-east Asian knowledge hub and is thus a significant research area where several multinational knowledge-intensive service firms operate.

Typically, the service innovations identified in the studied TEC firms were formed by several dimensions of innovations. In addition to technological aspects, innovations were, for instance, related to new client interfaces and service delivery processes. The main enablers of and barriers to innovation seem to be partly similar in Singaporean firms as compared to the earlier study of Finnish TEC firms. They include factors such as a wide technological knowledge-base and experience, trust, use of cross-disciplinary forums, a strong emphasis on real world problems and customer needs and expectations as a basis for innovations, a lack of resources, as well as internal conventional routines for carrying out the engineering and consulting work. Moreover, some T-KIBS- and industry-specific characteristics, such as increased competition, internationalization and consolidation, project-oriented thinking of business and strong customer bargaining power, also need to be taken into account in the analysis of TEC firms.

Empirical studies also brought forth the significance of various sources of knowledge and knowledge processing activities as the main driving forces of service innovation in technology-related KIBS firms. We developed a framework to study the effect of knowledge processing capabilities as well as some moderators on the innovativeness of TEC firms. Especially efficient knowledge acquisition and environmental dynamism seem to influence the innovativeness of TEC firms positively, as reported in Tan's (2007) dissertation. The results of the study also contribute to the present service innovation literature by focusing more on "innovation within KIBS" rather than "innovation through KIBS", which has been the typical viewpoint stressed in the previous literature.

The basic framework for further studies has also been constructed on the basis of extensive literature reviews as well as case studies and secondary data sources. In future studies, the focus of research is on investigating how KIBS – especially technology-related KIBS – innovate, and how the internal and external knowledge and IHIP characteristics affect service innovation in KIBS. The results are expected to complement the existing theory on service innovation and knowledge management in KIBS as well as to bring managerial implications by providing insights that facilitate innovation in firms. A combination of case studies and surveys was adopted as the research methodology in an extensive study of which this study is a part. The next step in the whole research is to develop detailed hypotheses based on the

literature review and preliminary empirical analyses. A large-scale survey is then planned to be conducted in technology-related KIBS to test the hypotheses.

## **ACKNOWLEDGEMENTS**

The author is grateful to all collaborative parties and funding organizations. Financial support in different stages of the research is highly appreciated. The funding from the Academy of Finland for a research period in Singapore in 2006 deserves a special mention. Financial support from Viipurin taloudellinen korkeakouluseura (Tuomo Rönkkö grant, 2005) and Liikesivistysrahasto (2006) is also greatly appreciated.

I would especially like to thank Dr Chai Kah Hin, Ms Xin Yan and Mr Tan Lai Huat, Ivan from NUS for making this whole research possible through their collaboration. Many LUT colleagues, especially Dr Marko Torkkeli and Mr Pekka Salmi have also greatly contributed to this research already from the time of the Tekes-funded 3E research project (2004-2006). Finally, the author thanks all the companies involved in this research, and other collaborative parties not mentioned separately.

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