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Service Technology: Definition and Characteristics Based on a Patent Database

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Abstract. With the rise of service innovation, service is no longer considered peripheral to the business environment, and is increasingly being seen as a core offering to customers. Technology has played a central role in the rise of service innovation, but previous studies on service technology have discussed mostly qualitative approaches. For this reason, the concept of "a service technology" has not been properly defined based on the large amount of empirical evidence. To address this limitation, we define and characterize service technologies using patents to come up with a consensus and adopt a five-step process that embraces three viewpoints on the notion of service technology: the industry, patent, and technology perspectives. First, service industries are defined based on their International Standard Industrial Classification system categories, as prepared by the United Nations Statistics Division. Second, relevant service patents are extracted from the U.S. Patent and Trademark Office database for each service industry. Third, the International Patent Classification classes are obtained from these collected patents to investigate the technologies employed in service industries. Fourth, service technologies are defined and classified into six categories based on this patent classification analysis. Finally, the technological concentration and generality characteristics of each technology are analyzed.

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Keywords: service technology • patent • definition • classification

1. Introduction

Firms nowadays compete on the basis of offering services, and not just physical products (Gallouj and Weinstein 1997, Sundbo 1998, Gronroos 2000, Kandampully 2002). Services are no longer considered as peripheral in the business environment, but are increasingly seen as core customer offerings. Contrary to the long-held belief that services are low technology activities, the service sector is now a major user of research and development (R&D)-intensive outputs such as information and communication technologies (ICTs) (Amable and Palombarini 1998).

Revolutionary technological developments have been especially important in the rise of service innovation (Van den Ende and Wijnberg 2001, Karwan and Markl 2006, Chou and Shao 2014). Technological advances have altered how customers and service providers interact, and so influenced customers' perceptions of their service experience (Huete and Roth 1988, Van den Ende and Wijnberg 2001, Oliveira et al. 2002, Froehle and Roth 2004). For example, such advances have been used to enable customization processes (Bitner et al. 2000), manage development processes more effectively (Haynes and Thies 1991, Stock and Tatikonda 2004, Schilling and Hill 1998, Ulrich and Eppinger 2000), increase the productivity of service operations (De Vries 2006), and provide customer services after product purchase (Bitner et al. 2000, Froehle and Roth 2004). Technology-based communication channels (e.g., ICTs) have recently become essential in providing and enhancing customer services, which have led much literature and practice to emphasize the role of self-service technologies (Haynes and Thies 1991, Bitner et al. 2000, Froehle and Roth 2004). ICTs closely related to production process elements have been associated with productivity improvements (Boone and Ganeshan 2001, Chang et al. 2012, Chou and Shao 2014). This happens in many different service sectors where many innovations are driven by the advances of information technology (IT) capability, such as radio frequency identification–based logistics (Dominguez-Péry et al. 2013), smart cities (Lee et al. 2013), and the mobile industry (Kim et al. 2014). Such evidence suggests that many kinds of services cannot be realized without the help of facilitating technology, so few would question

that in-depth investigation of the role of technology in service businesses is critical to understanding the nature of service innovation.

However, the technologies that facilitate service businesses are quite different from manufacturing technologies, which are generally domain specific and highly specialized. In most cases, manufacturing technologies are directly applied to new product development—to provide products with more and diversified functions or contribute to making new product development processes quicker and more efficient. Compared to those applied in manufacturing, service technologies have different characteristics in terms of purpose, role, and the domains of their application, and work as enablers for both employees and customers, providing customization and making service operations more effective, and so enhancing customer satisfaction (Bitner et al. 2000, Kandampully 2002, Menor et al. 2002, Van Riel and Lievens 2004). ITs also play a substantial role in service business (Chadee and Pang 2008, Ruiz-Molina et al. 2011), especially their inherent database facilities, which can allow key customer information to be shared and used for firms' operational and marketing processes (Chadee and Pang 2008, Ruiz-Molina et al. 2011).

Despite the differences in how technologies are used in service and manufacturing settings, "technology" has been discussed as a general term, and the literature has not differentiated types and characteristics of technologies in terms of their application to service domains. Nor has the use of technologies in service industries been systematically investigated: most significantly, even the term "service technology" has been seldom discussed, so its definition is still in question. Even if some studies have considered technology in services, they have focused on how technologies can change the traditional service industry, focusing on the role of technologies in facilitating service delivery (Bitner et al. 2000, Froehle and Roth 2004). In addition, studies on service technology have relied on the "qualitative ways," such as explaining case examples of service technologies or suggesting types of service technologies based on their roles.

In explaining service innovation, previous research has been focused on a specific class of patents, class 705 of the U.S. Patent and Trademark Office (USPTO) patent database (Koda 2000, Han et al. 2011). This class is named business method (BM) patents, which are defined as methods of administering, managing, or operating an enterprise or organization (Koda 2000, Han et al. 2011). These BM patents have been employed to describe the real-world business models of manufacturing and service in electronic environments, and thus have been utilized as useful sources of information for innovating business processes (Han et al. 2011). Even if BM patents have been utilized as service patents in the previous literature, it is hard to consider these patents as service technologies for the following reasons.

First, since BM patents explain business models of both manufacturing and services, this is not representative of service technology. Second, the main scope of BM patents is related to electronic-based business model innovation (Han et al. 2011). However, not every service innovation happens in the electronic environment. Service technology can be effectively applied to traditional off-line businesses by enhancing communication channels, customer interaction, and service provision. Third, service technology is applied not only to creating new business models and methods but also to enhancing, developing, and creating new types of innovations. Therefore, BM patents are not a representation of service technology.

The purpose of this paper is to define the concept of "service technology" based on empirical and practical evidence to come up with a consensus as to the definition of characteristics of service technology. For this reason, the study employs a patent database to identify and characterize service technologies in a quantitative and analytic way. Using a patent database as a proxy for technology, the term "service technology" is defined via a systematic patent analysis based on patent class information, and the characteristics of service technologies are investigated in detail.

The remainder of this study is organized as follows. Section 2 outlines the background of service technology and patent analysis, and Section 3 presents our proposed approach and procedure. Section 4 discusses the study's findings, while Section 5 offers some conclusions.

2. Literature Review

2.1. Service Innovation

Service innovation is defined as new or considerably changed service concepts, client interaction channels, service delivery systems, or technological concepts that individually—but most likely in combination—lead to one or more new service functions (Van Ark et al. 2003). Service innovation generally encompasses four dimensions: (1) new service concept, (2) new client interface, (3) new service delivery system, and (4) new technological options (Den Hertog 2000). The notion has been discussed in terms of distinctive service characteristics, of its theoretical foundations and of practical considerations (Drejer 2004); the innate characteristics of services—intangibility, heterogeneity, inseparability, and perishability—have been discussed in the service innovation

literature; and (since the notion of service inevitably involves customers) the customer-oriented characteristics of service have also been discussed as a key issue (Edvardsson et al. 1994, Fitzsimmons and Fitzsimmons 1994, Fließa and Kleinaltenkamp 2004).

Three different approaches exist in discussing service innovation (Gallouj 1994), which have been widely adopted in the existing studies (e.g., Coombs and Miles 2000, Drejer 2004, Droege et al. 2009). The first is *assimilation* (e.g., Archibugi et al. 1994, Djellal and Gallouj 2000, Hughes and Wood 2000), which demonstrates that there are more similarities than differences between product and service innovation in terms of many of their basic innovation process dimensions (Hughes and Wood 2000, Sirilli and Evangelista 1998). Hence, assimilation is "a theoretical perspective that ignores the differences between goods and services in the field of innovation and, for the most part, focuses on technological innovation" (Gallouj and Djellal 2015). A representative method is demonstrated in the second European Community Innovation Survey (1997), which applies definitions and questionnaires that were developed for researching manufacturing activities to service settings (Djellal and Gallouj 2000).

The second approach is *demarcation* (e.g., Sundbo 1998, 2000; Sundbo and Gallouj 1998, 2000; Gallouj 2000; Djellal and Gallouj 2001), which, rather than comparing innovation in services directly with that in manufacturing, deals with the distinctive characteristics of services, and is mainly conducted via an autonomous survey, such as "Innovation in Services and Services in Innovation" (Sundbo and Gallouj 1998). According to this approach, "it is inappropriate to study service innovation activities by only mobilizing conceptual and empirical tools that are mainly developed for technical-based activities (e.g., R&D, patents, and accumulation of capital)" (Morrar 2014, p. 10). Thus, the demarcation approach could produce new typologies for innovation in services that consider nontechnological innovation (e.g., organizational innovation and marketing innovation).

The final approach is one of *synthesis* (e.g., Gallouj and Weinstein 1997, Preissl 2000), which suggests a combined approach to service and manufacturing innovation by taking the assimilation and demarcation approaches into one integrated conceptual framework. This approach can consider both technological and nontechnological innovation and has been especially useful recently as the boundaries between products and services have become blurred under the concept of servitization of products (Howells 2006) or productization of services (Harkonen et al. 2015). Salter and Tether (2006, p. 9) also mentioned that the synthesis approach "highlights the increasing complex and multidimensional character of modern services and manufacturing, including the increasing bundling of services and manufacturing into solutions." Quite naturally, most of the recent works on innovation in services adopted this synthesis approach (e.g., Gebauer 2008, Ulaga and Reinartz 2011).

Later, a new approach of *inversion* that addresses the role of knowledge-intensive business service (KIBS; e.g., consulting, engineering and R&D services) was added to the triad and has enriched the perspectives of service innovation (e.g., Gallouj 2010). KIBS innovation has a distinguishing feature in that the service providers play a significant role in the innovation of their clients. It shows "a shift of the domination relationship between goods and services by focusing on the strategic role of certain services (KIBS) in the innovation dynamics of their customers (especially industrial customers)" (Gallouj and Djellal 2015).

Among these approaches, the most referenced and debated approach is assimilation (Gallouj and Djellal 2015). This study also belongs to this category by adopting a patent database as a primary source for analysis. One of the earliest attempts in this area was the work by Barras (1986), who first defined the theory of innovation in services suggesting the reverse product cycle model. Later, Miles (1993) investigated the industrialization trajectory of service activities and the potential of innovation through their interaction with ICTs. However, the second notable attempt was the work by Miozzo and Soete (2001), who argued that the technology trajectories in services vary by sector—supplier dominated sectors, production-intensive sectors having two subsectors of scale-intensive and network sectors, and specialized technology suppliers and science-based sectors. Indeed, technology has been considered as an important factor in studying service innovation, as it facilitates effective customer–supplier interactions and efficient service operations (Kandampully 2002, Menor et al. 2002, Van Riel and Lievens 2004, Dominguez-Péry et al. 2013, Chou and Shao 2014): advances in IT have been particularly significant in promoting service innovation. Considering the role of technology for service innovation, it will be worthwhile to investigate patents in service industries as a proxy for service innovation, from the assimilation perspective.

2.2. Service Technology

Much research has discussed technology as a product-related term—this is natural enough, since technological advances have long driven product development. From the product perspective, technologies have been regarded as a means for managing new product development processes (Schilling and Hill 1998, Ulrich and Eppinger 2000, Wheelwright and Clark 1992). However, with the rise of service industries, technology has been

successfully implemented and utilized by both customers and providers in recent service businesses. Investment in ICT more than doubled between 1995 and 1999 to $510 billion in the United States alone (Curran and Meuter 2005), and services are major users of ICTs, which have been associated with the most important technological changes over the past 20 years (Amable and Palombarini 1998). A major feature of the technologies involved in service activities is that they often take the form of knowledge and skills embodied in individuals, which are implemented directly when each service transaction occurs (Gallouj and Weinstein 1997).

Technologies in service industries have been considered as the means for providing new types of business such as customization (Bitner et al. 2000), new service offerings or processes (Bitner et al. 2000, Froehle and Roth 2004), or new types of service encounters (Bitner et al. 2000, Froehle and Roth 2004), but, despite this range of attention, most research has focused on the role of technologies in facilitating service delivery. But, unfortunately, past studies have not clearly defined the concept of "service technology," so this important question should be addressed: *What is a service technology and what kinds of service technologies exist*?

2.3. Patent Analysis

To define and characterize service technologies, a patent database is employed. Patents are considered to be a category of direct outputs of industrial R&D and of other inventive activities, and to mirror the cumulative processes of technological change (Von Wartburg et al. 2005). Previous literature has been almost unanimous in employing patent databases as a proxy measure for technology: given that up to 80% of all technological knowledge can be assumed to be entailed in patents, they can be regarded as a solid basis for such monitoring (Teichert and Mittermayer 2002). Patent databases provide an ample source of technical and commercial knowledge, besides offering numerous advantages such as easy availability, scope of coverage, and richness of information (Yoon and Park 2004).

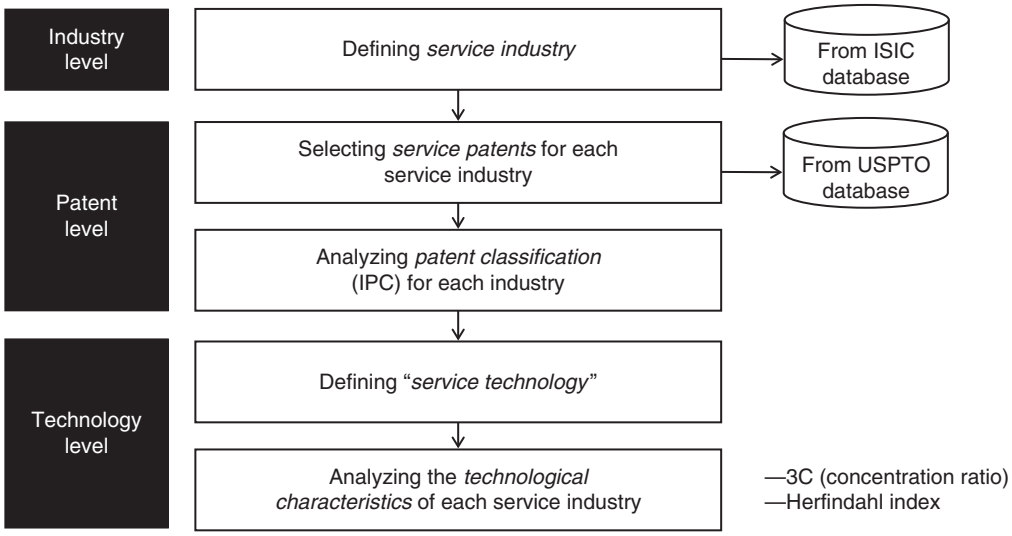
The strategic importance of patent analysis has become more apparent recently as innovation processes have become more complex, innovation cycles shorter, and market demand more volatile (Park et al. 2005). Patent analysis utilizes diverse and complex bibliometric data, so special techniques are required to manipulate and analyze patent statistics. Several scenarios or processes can be applied to analyze patent information: task identification, searching, segmentation, abstracting, clustering, visualization, and interpretation (Tseng et al. 2007), and many techniques have been employed to identify technological information from patents. Of these, patent citation analysis—a development of bibliometric analysis—has been an important method used to analyze relationships among technologies. Indexes such as citing-cited intensity and linkages, technology coverage, and citation cycle times have been continuously developed as citation analysis measures (Tijssen 2001, Park et al. 2005).

Another important source for analyzing technological characteristics is patent classifications, which refers to the way patent office examiners arrange patent documents according to the technical features of the inventions involved (Geum et al. 2012), with the result that patent classes provide clear and meaningful information via which to characterize a patent's technological features, or the distinctive features of a certain technology (Tijssen 1992, Engelsman and van Raan 1994, Larkey 1999, Breitzman and Mogee 2002, Leydesdorff 2008, Geum et al. 2012). The USPTO classifies U.S. patents into a hierarchically structured scheme containing around 400 classes and around 135,000 subclasses (Larkey 1999), covering a wide range of technological fields (Kim and Lee 2015). The patent documents themselves provide more diversified and specific information, and—since the same documents may be classified into several classes—coclassification can be used to identify relationships between technologies (Tijssen 1992, Engelsman and van Raan 1994, Curran and Leker 2011, Geum et al. 2012). Classes with high coclassification frequencies are likely to contain patents with similar characteristics, and coclassification—or coinventions in Standard Industrial Classification (SIC), International Patent Classification (IPC), or U.S. Patent Classification (USPC) codes—can also provide an excellent measure of technological convergence by identifying knowledge spillover between two classes (Geum et al. 2012).

3. Proposed Approach

Figure 1 illustrates the five main elements of the proposed approach. First, service industries are defined according to the International Standard Industrial Classification of All Economic Activities (ISIC) system categories prepared by the United Nations Statistics Division, after which relevant service patents are extracted from the USPTO database based on these ISIC categories as the second step. Third, the IPC is obtained from each extracted patent, which is then used as a basis for defining and classifying service technologies in the fourth step. Based on these classifications, the characteristics of each class of service technology are analyzed based on their concentration ratios and Herfindahl indexes in the fifth step. This study therefore considers service technologies from three points of view—industry, patent, and technology.

Figure 1. Overall Process of Proposed Approach



3.1. Defining Service Industries

The first research step in this approach is to define the service industry. Despite considerable discussion regarding service industries in the literature, little previous research has identified service industries systematically with rigorous methods and large databases. This paper tries to address this problem by defining service industries based on their ISIC classifications.

Here, it is worth reviewing the definition of services before service industries are identified. The most widely adopted definition of services is the one introduced by Hill (1977, p. 318), where services are regarded as "a change in the condition of a person, or a good belonging to some economic unit, which is brought about as a result of the activity of some other economic unit, with the prior agreement of the former person or economic unit." Hill (1999, p. 31) put a particular emphasis on the relationships between producers and consumers and argued that "[i]n contrast to a good, a service is not an entity that can exist independently of its producer or consumer and therefore should not be treated as if it were some special kind of good, namely an 'immaterial' one." He distinguished services as intangible products, insisting that the distinction between goods and services should not be totally based on the distinction between tangible and intangible products. Gadrey (2000) took the definition by Hill (1999) and expanded it by suggesting the concept of "service triangle." According to this view, a service activity was defined as "an operation intended to bring about a change of state in a reality C that is owned or used by consumer B, the change being effected by service provider A at the request of B, and in many cases in collaboration with him or her, but without leading to the production of a good that can circulate in the economy independently of medium C" (Gadrey 2000, p. 259).

We adopt Vargo and Lusch's (2004, p. 2) approach to defining service industries. They defined services as "the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself." Since their definition focuses on the use of specialized competences in producing outputs by taking the view of industries, it was more applicable to identify service industries based on this definition rather than the other, more widespread alternatives. According to this definition, 10 ISIC categories were determined as service industries: accommodation and food, information and communications, financial and insurance, real estate, professional/scientific/technical, administrative, security, education, health, and art/entertainment services (shaded in grey in Table 1).

3.2. Selecting Service Patents

The next step is to select patents that represent the technologies involved in each service industry (as defined by their ISIC classifications) based on the relevant keywords. Since the choice of keywords could significantly affect our research results, the keyword selection process for each service industry was carefully designed. First, questionnaires were designed to identify the core keywords to represent the characteristics of each service industry and sent to industry experts qualified to give relevant answers. The respondents selected for this study were all experts in innovation, in the 10 relevant service categories, each with more than 5 years of experience. In all, 50 questionnaires were sent out and 27 were returned and analyzed (a 54% response rate). All the

Table 1. ISIC Classification (Service Industry Fields Highlighted in Grey)

Section	Division	Description	Further notation
A	01–03	Agriculture, forestry and fishing	
B	05–09	Mining and quarrying	
C	10–33	Manufacturing	
D	35	Electricity, gas, steam, and air conditioning supply	
E	36–39	Water supply; sewerage, waste management and remediation activities	
F	41–43	Construction	
G	45–47	Wholesale and retail trade; repair of motor vehicles and motorcycles	
H	49–53	Transportation and storage	
I	55–56	Accommodation and food service activities	Food
J	58–63	Information and communication	ICT
K	64–66	Financial and insurance activities	Finance
L	68	Real estate activities	Estate
M	69–75	Professional, scientific and technical activities	Professional
N	77–82	Administrative and support service activities	Administrative
O	84	Public administration and defense; compulsory social security	Public
P	85	Education	Education
Q	86–88	Human health and social work activities	Health
R	90–93	Arts, entertainment, and recreation	Art
S	94–96	Other service activities	Others
T	97–98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	
U	99	Activities of extraterritorial organizations and bodies	

keywords thus chosen were collected and analyzed, and those proposed by more than half the experts were adopted as the final keywords to represent each service industry. Table 2 shows final keyword lists derived from the questionnaires returned by the domain experts, which were then employed to collect the relevant patents for each service technology from the USPTO database. A total 9,092 patents were collected for the 10 service industry categories, the oldest of which dated back to 1973.

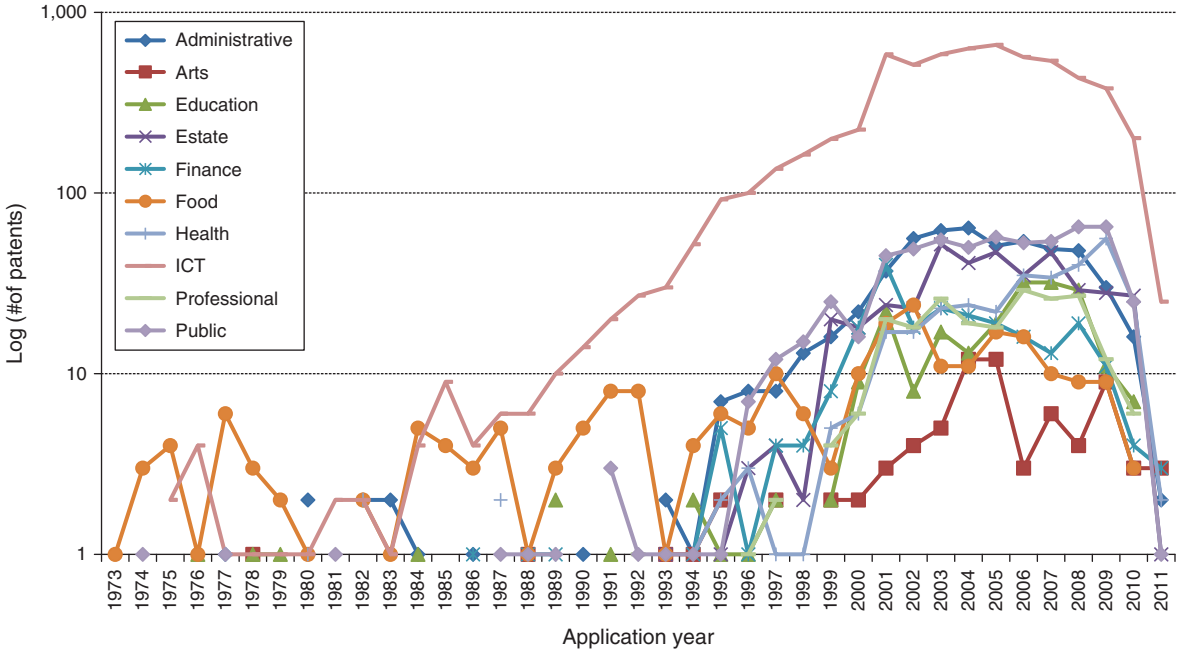
After the service patents for each sector were collected, the dynamic trends of technology patents in each service industry were investigated (as shown in Appendix A and illustrated in Figure 2). The horizontal axis in Figure 2 shows the years when the service patents were granted and the vertical axis shows the log scale of the number of service patents in that year. Since there were significant differences in number of patents between industries, the log scale was used to represent those differences clearly.

In general, the numbers of patents tends to increase from the mid-1990s. What is notable is the dominance of service patents in ICT industry, which represent a substantial proportion (over 68%) of the total of 9,092 technology patents granted. ICT patent numbers start to increase in the late 1990s, and show explosive growth in the early 2000s (especially between 2000 and 2001—the period of the "dot.com bubble"), reaching a peak in 2005, and decreasing thereafter. Patents in the food industry show a similar pattern to those in the ICT industry, but other industries appear not to have started employing technological options at that time. The increase in terms of the number of patents in the food sector becomes more prominent from the early 2000s, as it does in other industries. Technological advances in the arts/entertainment industry are shown as starting in the late 1990s and increasing in early 2000s, with technological factors being especially actively involved in artistic work in 2004 and 2005. In the education industry, the number of service technology patents has increased more recently, and shows significant growth between 2006 and 2008, apparently aligning with the active growth of

Table 2. Keywords for Selecting Service Technology Patents

Service industry	Relevant keywords	Count
Food	Accommodation, housing, shelter, lodging, restaurant, food, café, bistro, drink	240
ICT	Information, communication	6,227
Finance	Banking, commerce, trade, insurance	231
Estate	Real estate, estate, rent	403
Professional	Professional, consulting, science, technology	216
Administrative	Administrative, support	556
Public	Public, defense, social security	607
Education	Education, school, training, learning, teaching, guide, tutor	214
Health	Health, sanitary, hygienic, clean, social work, social welfare	322
Arts	Art, entertainment, sport, leisure, recreation	76

Figure 2. Dynamic Trends of Service Technologies for Each Industry



e-learning businesses, which require significant levels of technological involvement on the part of both suppliers and customers. This trend is also found in the finance industry. The finance industry shows strong growth in the early 2000s, which is a period that coincided with the emergence of Internet banking. This new banking system gained significant popularity, enabling the banking industry to engage in many kinds of service technologies.

3.3. Analyzing Patent Classification (IPCs)

The patents collected in the previous step were then analyzed to identify the dominant—i.e., the most frequently utilized—patent classification(s) (IPCs) in each service industry. Table 3 lists the top five patent IPCs for each service industry.

Electric digital data processing technology (class G06F) turned out to be the dominant technology in shaping the service business in most industries. This technology supports the effective information processing for service industry, operations, and communications, and so is significant in helping enhance service innovation. It has quite general characteristics, and so it can be applied effectively in many kinds of service industries that incorporate information or communication systems.

Investigating industry-specific characteristics yields more interesting results. First, the food service industry utilizes many different technologies, including those supporting data processing, containers, signaling, equipment, and machinery. Second, the ICT industry involves more than 68% of the total number of patents, and data processing, communication, and telephone technologies are identified as the top classes for this industry, while the dominant overall patent class—electric digital data processing—also turns out to be the dominant class in ICT industry. The other dominant classes are highly associated with data processing, e.g., communication and transmission technologies. In fact, the technological heterogeneity of patent classes in the ICT industry turns out to be lower than that of other industries. A significant portion of important technologies in the financial industry also relate to data processing, especially electronic data processing, which is unsurprising given that financial businesses now face e-commerce (and even m-commerce) challenges, so secure and effective data processing is key to the success of current financial businesses. This same phenomenon—the strong dominance of data processing technologies—can be also found in other industries, such as real estate, a characteristic of which is the fast processing of accurate information about land, and professional services, in which accurate and effective communication and data processing is again imperative.

The education industry also displayed many industry-specific technologies, such as those relating to pictorial communication and educational appliances. The art industry reveals an interesting result: the industry seems to attach significant importance to human effort, so one might expect it to be (comparatively) technology-free; but, in fact, many different technologies are employed to facilitate artistic work, including communication, representation, and data processing technologies.

Table 3. Top Five Patent Classes for Each Service Industry

Industry	IPC	Explanation	Count
Food	G06F	Electric digital data processing	32
	B65D	Containers for storage or transport of articles or materials	19
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	9
	G08B	Signaling or calling systems; order telegraphs; alarm systems	9
	A47B	Tables; desks; office furniture; cabinets; drawers; general details of furniture	6
	A47J	Kitchen equipment; coffee mills; spice mills; apparatus for making beverages	6
	B65B	Machines, apparatus or devices for, or methods of, packaging articles or materials; unpacking	6
	A47F	Special furniture, fittings, or accessories for shops, storehouses, bars, restaurants, or the like; paying counters	6
	H05B	Electric heating; electric lighting not otherwise provided for	6
ICT	G06F	Electric digital data processing	1,615
	H04Q	Selecting	969
	H04M	Telephonic communication	944
	H04L	Transmission of digital information	725
	H04B	Transmission	402
Finance	G06F	Electric digital data processing	116
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	86
	G07F	Coin-freed or like apparatus	7
	H04N	Pictorial communication	4
Real estate	G06F	Electric digital data processing	127
	H04M	Telephonic communication	59
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	49
	H04L	Transmission of digital information	40
	H04Q	Selecting	29
Professional	G06F	Electric digital data processing	112
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	42
	H04L	Transmission of digital information	11
	H04M	Telephonic communication	10
	H04Q	Selecting	8
Administrative	G06F	Electric digital data processing	214
	H04L	Transmission of digital information	90
	H04M	Telephonic communication	46
	H04Q	Selecting	36
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	31
Public	G06F	Electric digital data processing	233
	H04L	Transmission of digital information	145
	H04M	Telephonic communication	60
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	45
	H04Q	Selecting	36
Education	G06F	Electric digital data processing	69
	H04N	Pictorial communication	58
	G09B	Educational or demonstration appliances	15
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	14
	H04L	Transmission of digital information	6
Health	G06F	Electric digital data processing	144
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	91
	A61B	Diagnosis; surgery; identification	17
	H04M	Telephonic communication	13
	H04Q	Selecting	4
Arts	G06F	Electric digital data processing	26
	H04N	Pictorial communication	18
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	10
	A63F	Card, board, or roulette games; indoor games using small moving playing bodies	5
	H04M	Telephonic communication	4

Notes. Some industry classes had equal numbers of classes within the top five, and others had fewer than five classes. Some classes were represented in more than one industry.

3.4. Defining Service Technologies

To define a service technology, the top five patents classes in each industry were investigated to show the distinctive characteristics of each category. Based on the top five patent classes, we defined a service technology considering the characteristics of patent classes, especially the first letter and subsequent two digits of the patent classes. As a result, 12 service technologies were identified. Table 4 shows the results of this classification analysis, providing categories (which classify service technologies), patent classes, descriptions, numbers of total patents, and coverage (total number of relevant industries), and the 11 types of technologies: equipment-supporting technology, healthcare technology, game and entertainment technology, machinery technology, building technology, fluid technology, measurement technology, data processing technology, financial and trading technology, educational technology, and communication technology.

First, *equipment-supporting technology* relates to the development of facilities or household equipment; most are used to support and help people develop and utilize useful facilities in the food service industry. *Healthcare technologies* are also considered to be important service technologies, related to providing healthcare support

Table 4. Classification of Service Technologies

Category	Class	Description	Total patents	Coverage
Equipment-supporting technology	A47B	Tables; desks; office furniture; cabinets; drawers	6	1
	A47F	Special furniture, fittings, or accessories for shops, storehouses, bars, restaurants, or the like	6	1
	A47G	Household or table equipment	5	1
	A47J	Kitchen equipment; coffee mills; spice mills	6	1
Healthcare technology	A61B	Diagnosis; surgery; identification	17	1
Game and entertainment technology	A63F	Card, board, or roulette games; indoor games using small moving playing bodies	5	1
Machinery technology	B62B	Hand-propelled vehicles	5	1
	B65B	Machines, apparatus or devices for, or methods of, packaging articles or materials	6	1
	B65D	Containers for storage or transport of articles or materials	19	1
Building technology	E04H	Buildings or like structures for particular purpose	1	1
	E21B	Earth or rock drilling	3	1
Fluid technology	F04F	Pumping of fluid by direct contact of another fluid or by using inertia of fluid to be pumped	3	1
Measurement technology	G01C	Measuring distances, levels or bearings	5	1
	G01R	Measuring electric variables	5	1
	G05F	Systems for regulating electric or magnetic variables	1	1
Data processing technology	G06F	Electric digital data processing	2,688	10
	G06G	Analogue computers	3	1
	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes	642	10
	G06K	Recognition of data; presentation of data	11	3
	G08B	Signaling or calling systems	20	3
Financial and trading technology	G07F	Coin-freed or like apparatus	7	1
	G07G	Registering the receipt of cash, valuables, or tokens	2	1
Educational technology	G09B	Educational or demonstration appliances	15	1
Communication technology	H01R	Electrically conductive connections	4	1
	H04M	Telephonic communication	1,144	9
	H04Q	Selecting	1,089	9
	H04L	Transmission of digital information	1,022	8
	H04B	Transmission	445	5
	H04N	Pictorial communication	386	9
	H04W	Wireless communication networks	349	5
	H04J	Multiplex communication	269	5
	H04H	Broadcast communication	127	3
	H04R	Loudspeakers, microphones, gramophone pickups	1	1
	H05B	Electric heating	6	1

service or communicating with healthcare devices. *Game and entertainment technologies* are other important service technologies, providing platforms, methods, apparatuses, or computer programs in entertainment or social services. *Machinery technologies* are associated with machines or devices to pack and/or transport items. Rather than being key technologies for any specific service industry, they generally support a range of service industries, but are most actively utilized in the accommodation and food service sectors, supporting the effective operation of restaurants, cafes, and associated service facilities. *Building technologies* are used to build or form structures for particular purposes. While this group seem to be related to manufacturing activities, it also turns out that they are widely used across various service industries—the art industry especially employs this type of technology. Another type is *fluid technology*, which represents a small element of service technologies and relates to pumping fluids, which again might seem to be a manufacturing technology, but is also used in service industries in the human health and social work sectors. *Measurement technology*, even if it is quite manufacturing-related technology, is also employed as an important service technology. This is because many technology-based services such as healthcare services require comprehensive measurement systems and corresponding data processing systems. *Financial and trading technology* is related to the finance industry or trade industry, dealing with the registration of cash, valuables, or information. Technologies that are required to assist positional information services or automated travel service information systems are the representative examples. *Educational technology* is also identified as an important service technology, which supports decision making for learning services. This technology also includes various kinds of training aid conversion systems.

What is notable about the above types of technologies is that they all show comparatively low levels of usage. Their coverage of most the technologies in these groups, in terms of the number of service industries to which they are relevant, is very limited—they are generally very specific to certain industries. In contrast, the remaining two types—data processing technology and communication technology—show different results in terms of their coverage. First, *data processing technology* is employed in information systems to facilitate related service industry activities. Data processing technologies are widely applied across all 10 ISIC service industry categories, and thus have a significant impact on technology-based service industries, underlining that fact that information technologies cannot be separated from contemporary service business operations. Finally, *communication technology* enables active communication between service providers and customers. As with data processing, technologies in this category are scattered across various service industries, and are tightly coupled with today's service businesses. So they also exhibit broad coverage: many communication technologies are used in five ISIC categories, which means they are actively applied throughout most service industries.

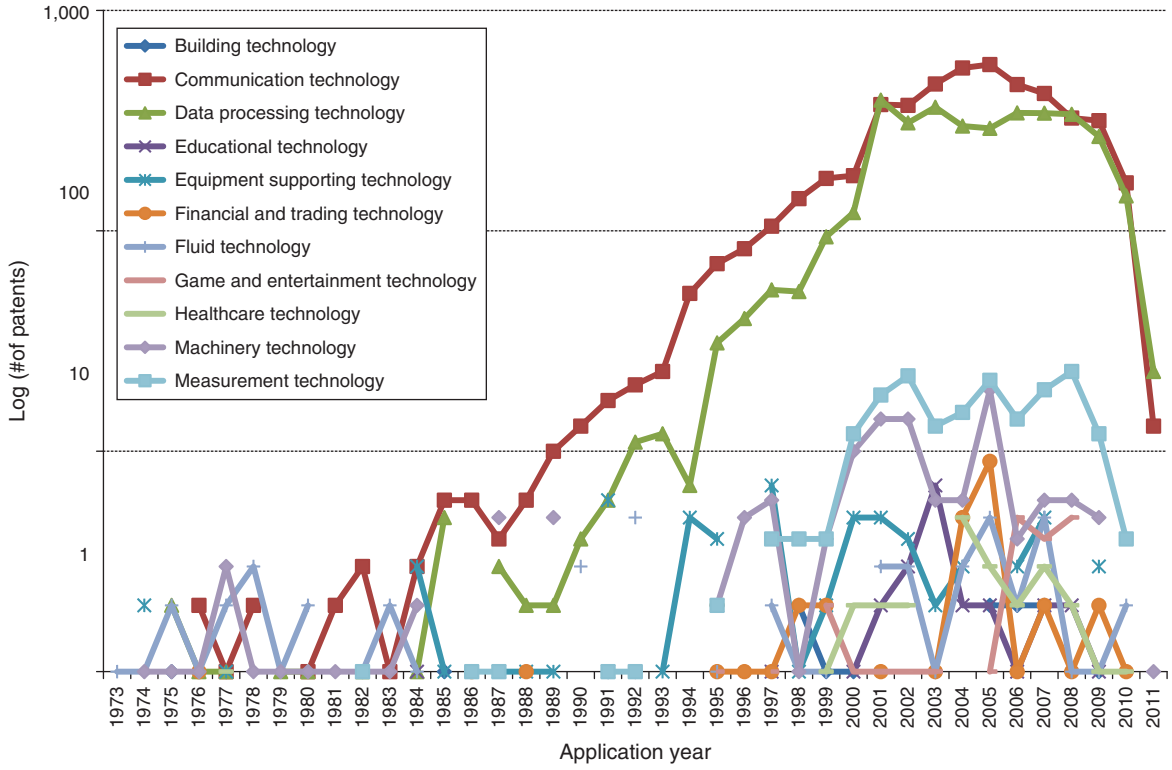
To investigate the dynamic trends of those service technologies, the changes in service technologies of each type are analyzed, as shown in Appendix B. Figure 3 illustrates the dynamic trends of those service technologies according to their type.

In general, data processing and communication technologies are the most commonly used technologies in service industries. Their numbers rapidly increased in the mid-1990s, reaching their high points in the mid-2000s, while others—such as education technologies and healthcare technologies—tended to grow from the mid-2000s, in line with the growth of the relevant industries. Manufacturing-originated technologies have been used in service industries, but, unlike the others, their use does not grow rapidly, even in the 2000s.

3.5. Analyzing the Characteristic of Service Technologies

3.5.1. Technological Concentration. As the final step, this section analyzes the characteristics of service technologies in each service industry by using CR3 (concentration ratio) and the Herfindahl index to identify their technological concentrations in each service industry. In economics, a concentration ratio is a measure of the total output produced in an industry by a given number of firms in the industry, and is usually used to show the extent of market control of the sector's largest firms. But it can also be used to establish the concentration of a technology in a specific industry, and this paper employs the CR3 concentration ratio, which measures the comparative importance of the three largest patent classes in an industry sector. Another indicator of market concentration is the Herfindahl index (also known as Herfindahl–Hirschman index (HHI)) which a measure of the size of firms in relation to the industry, which thus also shows the level of competition between them. It is defined as the sum of the squares of the market shares of all firms within the industry, where those shares are expressed as fractions. Increases (decreases) in the Herfindahl index generally indicate a decrease (increase) in competition and an increase (decrease) of the market power of the largest firms. Both the CR3 and Herfindahl index can be used to analyze the technological characteristics of a specific industry, revealing the impact of each technology within that industry; that is, if the index values in a particular industry are high, it is supported by a few dominating technologies, but if they are low, it has grown via diverse technology development. The results of our CR3 and Herfindahl index analyses are shown in Table 5 and Figure 4.

Figure 3. Dynamic Trends of Service Technology According to Type



The figure shows that the financial industry shows high CR3 and Herfindahl index values, indicating that its characteristics are determined by "big three" dominant technologies—in this case (as Table 3 showed) data processing technologies—which aligns with its recent emphasis on online businesses, so data processing technologies make up a substantial part of its operations. Other service industries, such as professional service, health, and public sectors, also show high CR3 and/or and Herfindahl index scores, implying that they, too, are driven by a fewer technologies which have higher impacts. In contrast, service industries such as food show low CR3 and Herfindahl index values, showing that they are affected by many technologies, and so display high levels of service technology heterogeneity. The food industry employs many different kinds of technologies, such as equipment-supporting, machinery, and data processing technologies.

3.5.2. Technological Generality. To investigate technological generality, the number of USPCs that were relevant for each service technology was investigated. This represents the relevant number of patent classifications attached to each patent, indicating the generality of its technology. Where this number is 1, the patent is associated with only a single classification, and so its application is limited to this class, and the technology can be considered as specific. But a high number of relevant USPCs means the technology in question is associated with many different classifications, and so is likely to have many different applications—in other words,

Table 5. Technological Concentration According to Industry

Industry	CR3	HHI
Food	0.3218	0.0532
ICT	0.5661	0.1396
Finance	0.9127	0.3995
Estate	0.5831	0.1580
Professional	0.7639	0.3155
Administrative	0.6375	0.1982
Public	0.7145	0.2202
Education	0.6636	0.1902
Health	0.7826	0.2853
Arts	0.7105	0.2029

Figure 4. Technological Concentration According to Industry

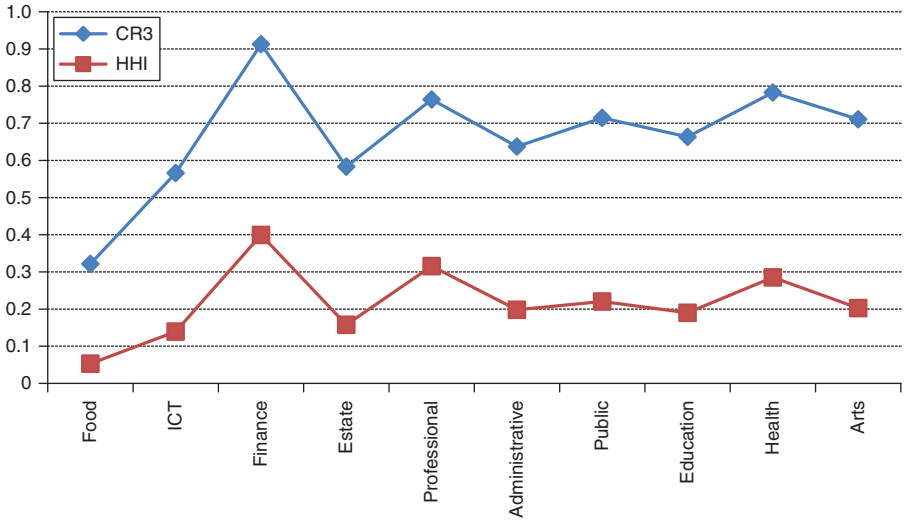
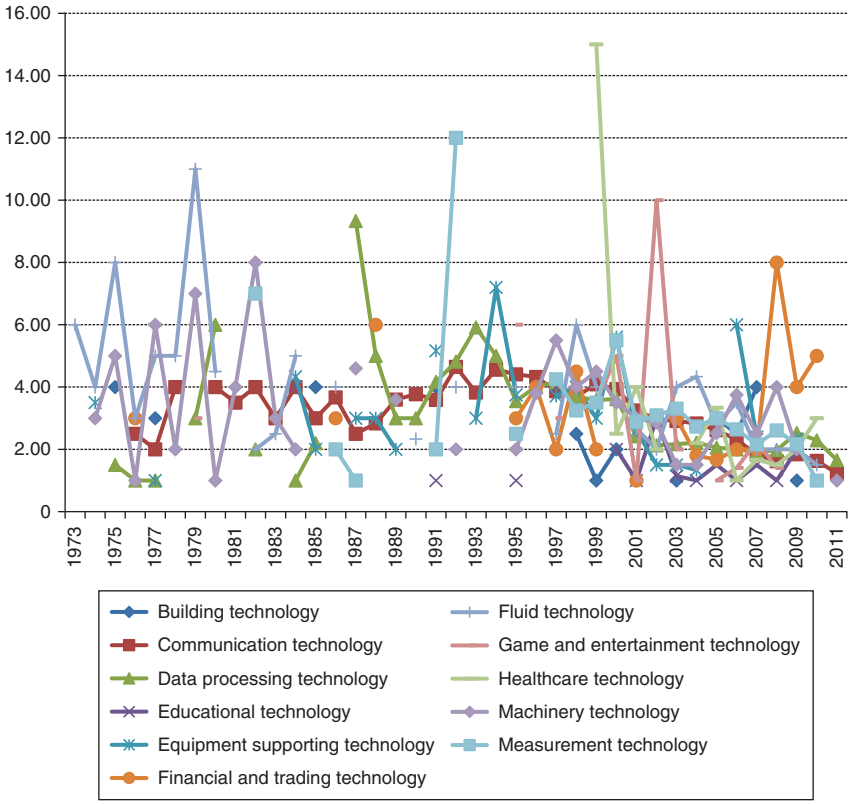


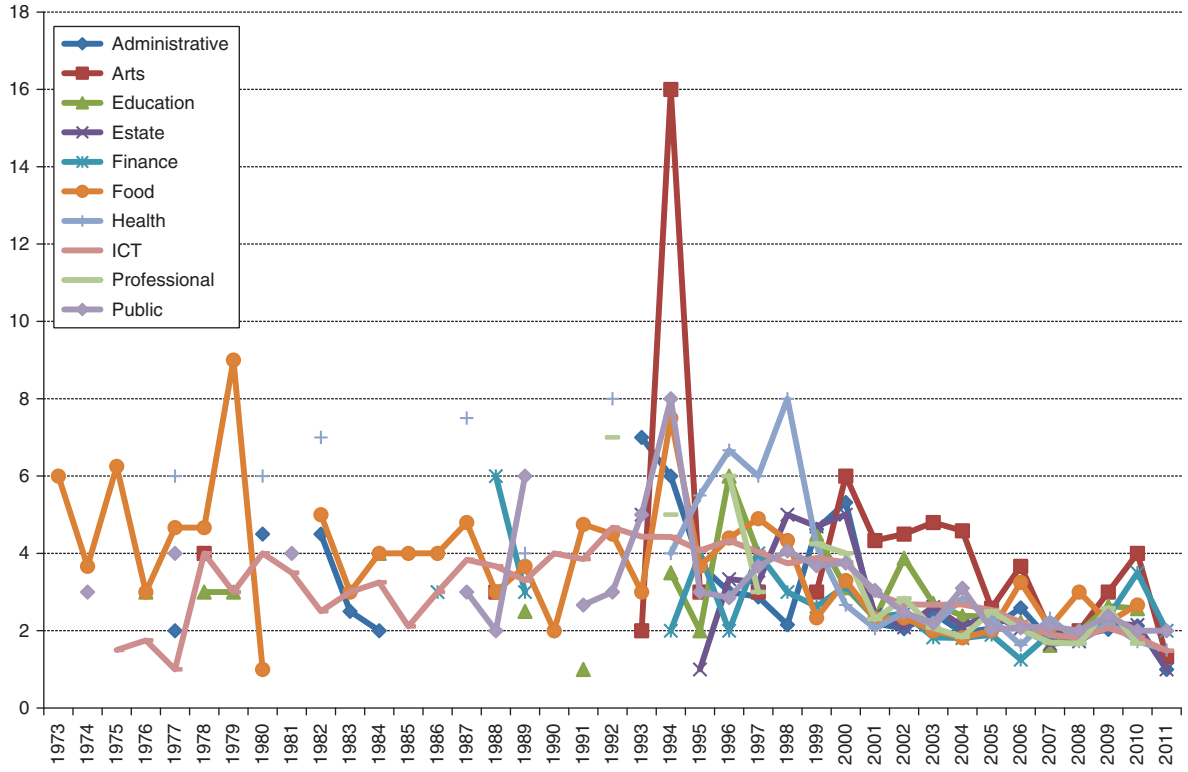
Figure 5. Technological Generality According to the Service Technology



it is a general technology. Appendix C presents our technological generality analysis results, and the dynamic changes in technological generality of the different service technologies are shown in Figure 5. In the figure, the y-axis is the number of relevant classifications for each technology. Figure 6 also shows the dynamic changes in technological generality of the different service industries.

Overall, most service technologies seem to be general in terms of their application (see Figure 6). For example, technological generality in the art industry seems to be very high, because the technologies involved tend not to originate from the art industry itself, but from other fields, and the same applies in the food and health

Figure 6. Technological Generality According to the Service Industry



industries, where technologies again seem to be general. However, most of these technologies have tended to change to become more specific over time—thus, technologies that have previously been employed in many different areas seem now to be finding a "fit" in some specific application areas. This implies that as service technologies grow and evolve, the scope of their applications tends to become more specific, until they finally build up their own classification scheme.

4. Discussion

4.1. Viewpoint of Defining Service Technology

Even if research on service technology itself has seldom been conducted, technology has been defined from many different perspectives, such as (1) the science or study of the practical industrial arts, (2) the terms used in a science, or technical terminology, and (3) applied science (Bozeman 2000).

Research on defining general technology can be conducted from three different perspectives: input, process, and output. Since this study employs a patent database to define service technology, the primary focus of defining technology is related to the output perspective. This means the definition is closely associated with where and how service technology is applied. For this purpose, we first defined "service industry" using an international standard classification to investigate the application areas of the service technology. From the output perspective, technology has been defined as the means by which an organization's outputs are created, which is concerned with operations technology to produce desired goods (Thompson and Bates 1957, p. 325; Marsh and Mannari 1981). Our study to define service technology is in line with this output perspective, focusing on how technology can produce desired outputs in service industries. This study can be further extended to the input and process perspectives to define service technology. From the input perspective, factors that affect the development of service technology can be considered. For instance, the dynamics of the service business environment, changes of customer requirements, socioeconomic factors, and adoption of precedent technologies should be included as important factors. From the process perspective, the ways and means by which service technologies are utilized can be an important research area.

Technology can be defined as both a conceptual notion and an operational notion (Fernandes 2012). The conceptual notion contains the semantic contents of a notion, whereas the operational notion, also a scientific

notion, allows the use of operations, procedures, and, most importantly, measurements (Morrow 1983, Chu 2008, Fernandes 2012). Since our study employs a patent database to define and categorize service technology, this is closely associated with the operational notion, which is a scientific and analytic notion.

4.2. Technology Concentration

The service technology identified in this research differs in terms of its concentration and generality. The concentration of service technology is very high in the finance industry (as shown in Figure 4), which means that a few technologies dominantly drive the innovation of the service industry in the finance industry. Starting from automated teller machines, many technology-based innovations have happened in the finance industry, such as telephone-based banking, Internet banking, and mobile banking. These technological innovations were possible because of the invention of new communication and delivery channels (Mishra and Bisht 2013, Shaikh and Karjaluoto 2015) that were critically related to the dominant service technology in this area: data processing and communication technology.

Technology concentration in the health and professional industries is also high, which means innovation in these industries is driven by a few technologies such as electric data processing technology, diagnosis technology, and communication technology. These dominant technologies are actively used for the ubiquitous healthcare (u-healthcare) system and telemedicine systems. Telemedicine is a kind of electronic process of the healthcare system that employs information and communication technologies (Kamsu-Foguem and Foguem 2014). Recently, healthcare technology has extended to mobile health (m-Health) technology, which refers to the incorporation of mobile computing into traditional healthcare, using many different devices such as medical sensors and portable devices (Kamsu-Foguem and Foguem 2014). Even if many different kinds of technologies are actively employed in healthcare services, what is at the core is data processing and communication technology, which means technology concentration in the health industry is expected to be high also in the future.

What is notable is the coexistence of many different technologies in the accommodation industry. This is due to the industry's broad scope, which encompasses various types of industries such as restaurants, food, and accommodation. For example, service technology in this industry encompasses many heterogeneous technologies, such as data processing technology (as proven to have the top usage in other industries), containers for storage/transport technology, table/desk/furniture-related technology, kitchen equipment/mill-related technology, electric heating and lighting technology, and technology related to hand-propelled machines. Technology concentration in the ICT industry is also low, indicating that many different types of technologies coexist. This seems to be a distinct characteristic of the ICT industry where a lot of different technologies (81 different technology classes) coexist. As a result, the Herfindahl index, which represents overall concentration, is very low compared to other industries. This heterogeneous technological characteristic, however, can deliver new opportunities for service innovation such as technology convergence. The ICT industry is a representative industry where the convergence between different technologies significantly increases (Hacklin et al. 2009).

4.3. Technology Generality

Our research on technology generality shows interesting results. Technology generality changes according to the rise and fall of a certain industry or sector. When a certain industry or sector flourishes, relevant technologies are widely used and extended to other domains, which results in high-level technology generality.

There is another interesting result. Technological generality of the art industry seemed to be very high in the mid-1990s. This is because service technology of the art or cultural industry does not stem from the art industry itself, but comes from other industries such as construction technology, machinery technology, or communication technology. This means that service technology that stems from other industries shows relatively high-level generality, which means diverse applicability to other industries as well.

In general, the technological generality of service technologies seems to be high (especially in equipment-supporting, machinery, and fluid technologies), which means they are employed in many different applications. A common characteristic among these technologies is that they are not, in fact, service originated, but stem from the manufacturing context, where again they are employed in many different settings: their application is general, and they can be utilized for many different service purposes. In contrast, communication technology and data processing technologies show a low or medium number of relevant USPCs, indicating that they are relatively specific. They tend to originate from service industry contexts: many are related to the USPC class 705, which is labeled as the business method patent class, defined as methods of administering, managing, or operating an enterprise or organization (Koda 2000, Han et al. 2011). As this definition implies, BM patents are strongly associated with the service industry.

What is notable is that most of these technologies have tended to change to become more specific over time. Service technologies are first employed in many different areas. As time goes on, these technologies find their fit to a certain industry context, and build up their own classification scheme.

4.4. Coexistence of Human and Technological Factors

Generally, industries that place a significant focus on the human factor tend to be quite conservative and emphasize their traditional ways of interaction, so technological developments in these industries have been less or slower than in others; but active technological involvement is also found in such settings. For example, the food sector has long been considered as a "pure" service industry, with successful customer contacts as the first and foremost guarantee of success, and thus are relatively free from technological consideration and dependent mainly on human efforts. But, despite these characteristics, a variety of technologies (such as equipment-supporting and machinery technologies) are utilized in the food service industry and enhance its effective and efficient operations. Technologies have similar impacts in the art industry—again, traditionally, one that attaches significant importance to human effort, and so where there would seem to be less room for technologies to contribute. But while the art industry has put great emphasis on human intuition and creativity, technological advances (such as in communication, representation, and data processing technologies) have also been employed to facilitate human artistic work, again serving to enhance a traditional domain whose main emphasis is human interaction or intuition.

4.5. Blurring Boundaries Between Manufacturing Technology and Service Technology

This study investigates technologies from the service perspective, but many of them (e.g., equipment, machinery, and fluid technologies) emanate from the manufacturing area. Even data processing and communication technologies, which represent a substantial proportion of the technologies used in service industries, are also strongly associated with manufacturing. This implies the possibility of active interaction between manufacturing and service technologies—in practice, many cases of technology use in service contexts are significantly associated with their use in manufacturing, and vice versa. So, besides the identified service technologies, many other manufacturing technologies may also offer the potential of being adapted for use in service industries—and, indeed, extended to provide unexpected utility to service industries. Therefore, firms developing new services or managing their current service operations should consider manufacturing technologies as well as the service technologies they already employ: even technologies from other traditional industries—such as agriculture, fishery, or mining—might be excellent candidates for use in service industries.

5. Conclusion

This paper aimed to define and characterize the notion of "service technology" systematically, by using a patent database via a five-step approach: defining the notion of service industry, collecting patents from a patent database, allocating them into their IPC patent classes, defining the service technology involved in each, and thus identifying, characterizing, and categorizing service technologies in a systemic manner. As a result, six types of service technologies were defined and their industry characteristics analyzed, which were then further investigated by measuring their concentration ratios and Herfindahl index scores. The six service technologies are named as equipment-supporting technology, machinery technology, building technology, fluid technology, data processing technology, and communication technology.

This study's contribution to the literature is threefold. First, this study is the first to pay specific attention to defining the notion of "a service technology." This is timely, as much of the literature continues to emphasize the use of technology in service organizations. For this purpose, measuring and even defining service technology is critical in service literatures. Especially, the use of a patent database to define and analyze service technology contributes to the fields by providing an objective and analytic view of defining service technology. Second, this study investigates how service technologies differ according to the industry and type. How service technologies work in terms of technology concentration and technology generality can provide significant managerial implications to the industry practice where technology plays a key role in shaping and restructuring industry innovations. Third, our study contributes to the fields in that this paper extends the scope and boundary of the service technology, not limiting the service technology to the BM patents as previous research did.

Despite its contributions, this paper is subject to some limitations. First, although patents have been widely employed as proxy measures for their associated technologies, they cannot fully describe the characteristics of service technologies. This is for many reasons. First, services often adopt technologies produced in other industries, especially in manufacturing industries. Therefore, the boundaries between service technologies and manufacturing technologies are still blurred. Second, because of the specific nature of R&D in services, patents

are seldom applied in the service sector. Even if some patent classes are considered to be meaningful to analyze technological innovation (e.g., USPC class 705), patents related to the service industries are still limited. Therefore, identifying other valuable sources to define service technologies and integrating this with patent databases will be helpful. Future research could employ additional data sources to cover their full scope. Second, this paper defines and classifies service technologies with respect to patent classifications, so those definitions and classifications mainly focus on their technological characteristics. Other classifications might also be derived by focusing on the business or application characteristics of service technologies, such as their roles in facilitating service processes. Third, this paper is highly dependent on the selection of keywords that are used to extract service technologies, so a more elaborated keyword selection process might contribute to a more in-depth investigation of service technologies. Finally, dynamic analysis can help us to understand the changing technological characteristics of service businesses, as the dominant technology or technology heterogeneity in a certain industry may well vary over time. Therefore, a fuller dynamic analysis would provide more valuable results to aid our understanding of service businesses and allow our suggested framework to work more effectively in practice situations.

Appendix A. Dynamic Trends of Service Technology for Each Industry

	Admin.	Arts	Education	Estate	Finance	Food	Health	ICT	Professional	Public	Sum
1973						1					1
1974						3				1	4
1975						4		2			6
1976			1			1		4			6
1977	1					6	1	1		1	10
1978		1	1			3		1			6
1979			1			2		1			4
1980	2					1	1	1			5
1981								2		1	3
1982	2					2	2	2			8
1983	2					1		1			4
1984	1		1			5		4			11
1985						4		9			13
1986	1				1	3		4			9
1987						5	2	6		1	14
1988		1			1	1		6		1	10
1989			2		1	3	1	10		1	18
1990	1					5		14			20
1991			1			8		20		3	32
1992						8	1	27	1	1	38
1993	2	1		1		1		30		1	36
1994	1	1	2		1	4	1	52	1	1	64
1995	7	2	1	1	5	6	2	92		1	117
1996	8		1	3	1	5	3	100	1	7	129
1997	8	2	2	4	4	10	1	136	2	12	181
1998	13			2	4	6	1	163		15	204
1999	16	2	2	20	8	3	5	199	4	25	284
2000	22	2	9	18	18	10	6	224	6	16	331
2001	37	3	22	24	40	19	17	585	20	45	812
2002	56	4	8	23	18	24	17	512	18	49	729
2003	62	5	17	52	23	11	23	586	26	55	860
2004	64	12	13	41	21	11	24	631	19	50	886
2005	51	12	19	47	19	17	22	660	18	57	922
2006	54	3	32	35	16	16	35	565	29	53	838
2007	49	6	32	47	13	10	34	539	26	54	810
2008	48	4	29	29	19	9	40	433	27	65	703
2009	30	9	11	28	11	9	56	379	12	65	610
2010	16	3	7	27	4	3	25	201	6	25	317
2011	2	3		1	3		2	25		1	37
Total	556	76	214	403	231	240	322	6,227	216	607	9,092

Appendix B. Dynamic Trends of Each Type of Service Technology

Year	Building technology	Communication technology	Data processing technology	Educational technology	Equipment-supporting technology	Financial and trading technology	Fluid technology	Game and entertainment technology	Healthcare technology	Machinery technology	Measurement technology
1973							1				
1974					2		1			1	
1975	1		2				2			1	
1976		2	1			1	1			1	
1977	1	1	1		1		2		1	3	
1978		2					3			1	
1979			1				1	1		1	
1980		1	1				2			1	
1981		2								1	
1982		3	1		1		1			1	1
1983		1					2			1	
1984		3	1	1	3		1			2	
1985	1	6	5		1						
1986		6				1	1				1
1987		4	3		1					5	1
1988		6	2		1	1					
1989		10	2		1					5	
1990		13	4				3				
1991	1	17	6	1	6						1
1992		20	11				5			1	1
1993		23	12		1						
1994		52	7		5						
1995		71	31	2	4	1	1	1	2	2	2
1996		83	40			1				5	
1997		105	54	1	7	1	2	1		6	4
1998	2	140	53		1	2	1			1	4
1999	1	173	94		2	2	1	2	1	4	4
2000	1	178	121	1	5			1	2	10	12
2001		374	392	2	5	1	3	1	2	14	18
2002		371	309	3	4		3	1	2	14	22
2003	1	464	364	7	2	1	1	1		6	13
2004		548	299	2	3	5	3		5	6	15
2005	2	568	292	2		9	5	1	3	19	21
2006	2	461	343	1	3	1	2	5	2	4	14
2007	2	420	342	2	5	2	5	4	3	6	19
2008		325	338	2		1	1	5	2	6	23
2009	1	316	268	1	3	2	1		1	5	12
2010		165	144			1	2		1		4
2011		13	23							1	
Total	16	4,947	3,567	28	67	33	57	24	27	134	192

Appendix C. Number of Relevant USPCs for Each Type of Service Technology

Year	Building technology	Communication technology	Data processing technology	Educational technology	Equipment-supporting technology	Financial and trading technology	Fluid technology	Game and entertainment technology	Healthcare technology	Machinery technology	Measurement technology
1973							6.00				
1974					3.50		4.00			3.00	
1975	4.00		1.50				8.00			5.00	
1976		2.50	1.00			3.00	3.00			1.00	
1977	3.00	2.00	1.00		1.00		5.00		6.00	6.00	
1978		4.00					5.00			2.00	
1979			3.00				11.00	3.00		7.00	
1980		4.00	6.00				4.50			1.00	
1981		3.50								4.00	
1982		4.00	2.00		7.00		2.00			8.00	7.00
1983		3.00					2.50			3.00	
1984		4.00	1.00	4.00	4.33		5.00			2.00	
1985	4.00	3.00	2.20		2.00						
1986		3.67				3.00	4.00				2.00
1987		2.50	9.33		3.00					4.60	1.00
1988		2.83	5.00		3.00	6.00					
1989		3.60	3.00		2.00					3.60	
1990		3.77	3.00				2.33				
1991	4.00	3.59	4.17	1.00	5.17						2.00
1992		4.65	4.82				4.00			2.00	12.00
1993		3.83	5.92		3.00						
1994		4.56	5.00		7.20						
1995		4.41	3.55	1.00	3.75	3.00	4.00	6.00	2.00	2.00	2.50
1996		4.33	4.03			4.00				3.80	
1997		3.87	4.15	4.00	3.71	2.00	2.50	3.00		5.50	4.25
1998	2.50	3.71	3.68		4.00	4.50	6.00			4.00	3.25
1999	1.00	4.09	3.59		3.00	2.00	4.00	3.50	15.00	4.50	3.50
2000	2.00	3.94	3.61	2.00	5.60			5.00	2.50	3.50	5.50
2001		3.25	2.42	1.00	2.60	1.00	2.67	1.00	4.00	3.00	2.89
2002		2.96	2.13	3.00	1.50		2.00	10.00	2.00	2.86	3.09
2003	1.00	2.91	2.17	1.14	1.50	3.00	4.00	2.00		1.50	3.31
2004		2.83	2.21	1.00	1.33	1.80	4.33		2.20	1.50	2.73
2005	3.00	2.62	2.05	1.50		1.67	2.80	1.00	3.33	2.53	3.00
2006	2.50	2.31	2.00	1.00	6.00	2.00	3.50	1.40	1.00	3.75	2.64
2007	4.00	1.83	1.90	1.50	2.40	2.00	2.00	2.25	1.67	2.50	2.16
2008		1.62	1.97	1.00		8.00	2.00	1.40	1.50	4.00	2.61
2009	1.00	1.84	2.53	2.00	2.33	4.00	2.00		2.00	2.00	2.17
2010		1.63	2.29			5.00	1.50		3.00		1.00
2011		1.23	1.65							1.00	

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