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From data to value: A nine-factor framework for data-based value creation in information-intensive services

Chiehyeon Lim[a,*], Ki-Hun Kim[b], Min-Jun Kim[c], Jun-Yeon Heo[c], Kwang-Jae Kim[b], Paul P. Maglio[d]

[a] School of Management Engineering and School of Business Administration, Ulsan National Institute of Science and Technology, 50 Unist-gil, Eonyang-eup, Ulju-gun, Ulsan 44919, Republic of Korea

[b] Department of Industrial and Management Engineering, Pohang University of Science and Technology, San 31, Hyoja-dong, Nam-gu, Pohang, Gyeongbuk, 790-784, Republic of Korea

[c] Samsung Electronics R&D Center, 33, Seongchon-gil, Seocho-gu, Seoul, 06765, Republic of Korea

[d] School of Engineering, University of California, Merced, 5200 North Lake Rd, Merced California, 95343, USA

A R T I C L E I N F O

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A B S T R A C T

Service is a key context for the application of IT, as IT digitizes information interactions in service and facilitates value creation, thereby contributing to service innovation. The recent proliferation of big data provides numerous opportunities for information-intensive services (IISs), in which information interactions exert the greatest effect on value creation. In the modern data-rich economy, understanding mechanisms and related factors of data-based value creation in IISs is essential for using IT to improve such services. This study identified nine key factors that characterize this data-based value creation: (1) data source, (2) data collection, (3) data, (4) data analysis, (5) information on the data source, (6) information delivery, (7) customer (information user), (8) value in information use, and (9) provider network. These factors were identified and defined through six action research projects with industry and government that used specific datasets to design new IISs and by analyzing data usage in 149 IIS cases. This paper demonstrates the usefulness of these factors for describing, analyzing, and designing the entire value creation chain, from data collection to value creation, in IISs. The main contribution of this study is to provide a simple yet comprehensive and empirically tested basis for the use and management of data to facilitate service value creation.

1. Introduction

Service is a key context for the application of IT (Berkley & Gupta, 1994; Lim & Kim, 2015; Rai & Sambamurthy, 2006; Watanabe & Mochimaru, 2017). IT digitizes the information interactions within a service (Karmarkar & Apte, 2007) and facilitates value creation (Lim & Kim, 2014), thereby contributing to service innovation (Barrett, Davidson, Prabhu, & Vargo, 2015). An information-intensive service (IIS) is a type of service in which value is created primarily via information interactions, rather than physical and interpersonal interactions, between the customer and the provider (Karmarkar & Apte, 2007; Lim & Kim, 2014). Given advances in data collection technologies, various types and massive quantities of data are collected routinely in multiple industries (Atzori, Iera, & Morabito, 2010; Gandomi & Haider, 2015). The proliferation of big data provides numerous opportunities for IISs (Lim, Kim, Kim, Kim, & Maglio, 2017). For example, automobile manufacturers use large databases containing data about the vehicles' condition and operations, which are collected from onboard sensors; these data are used to assist drivers by providing them with useful information on fuel efficiency, safety, consumables, and navigation (Lim, Kim, Heo, & Kim, 2015). Insurance companies collect patient data to provide patients with health-related information to improve healthcare safety, reduce costs, and develop relationships with them (OECD, 2013).

Accordingly, an understanding of data-based value creation in IISs is essential for improving service value creation with data in the modern data-rich economy. However, a large gap exists in the literature between data and value creation despite the fact that data-based value creation has already been on scholars' and practitioners' agenda for some time, particularly in the context of big data (Ekbia et al., 2015; Lim, Kim et al., 2017; Maglio & Lim, 2016; Ostrom, Parasuraman, Bowen, Patricio, & Voss, 2015; ur Rehman, Chang, Batool, & Wah, 2016; Yaqoob et al., 2016). In this paper, a framework is provided to fill this gap. Specifically, we provide a framework of the essential *factors* that characterize data-based value creation, named the “Data–Value Chain.” A factor is “one of the things that determines or affects an

* Corresponding author.
E-mail address: chlim@unist.ac.kr (C. Lim).

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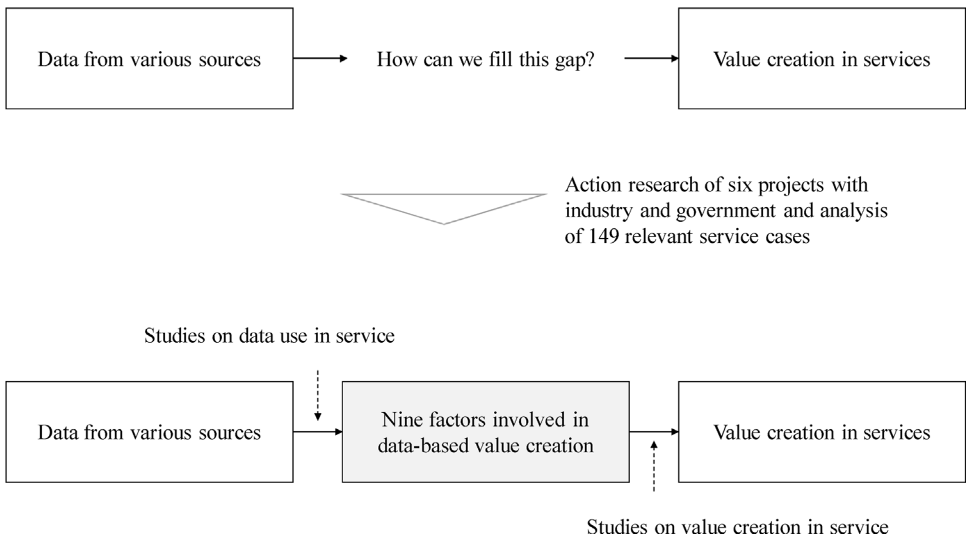


Fig. 1. Research overview.

event, decision, or situation" (Collins Cobuild, 2009); the identification and use of the key factors related to a system is a well-known method for structured system analysis and design (Ritchey, 1998). Factor identification has been used for the effective management of IT (Trkman, 2010) and service (Zomerdijk & Voss, 2010). To the best of our knowledge, however, factors characterizing data-based value creation in IISs are not well known; in fact, there have been few empirical studies on the management of data and information for service innovation, despite the significance of this topic (Lim, Kim et al., 2017; Nambisan, 2013; Ostrom et al., 2015).

This paper identifies nine key factors that characterize data-based value creation in IISs: (1) data source, (2) data collection, (3) data, (4) data analysis, (5) information on the data source, (6) information delivery, (7) customer (information user), (8) value in information use, and (9) provider network. Fig. 1 summarizes the context and contribution of our research. These nine factors were identified and defined through our action research with industry and government, analysis of data usage in 149 IIS cases, and review of studies on data usage and value creation in service. "Using data to create value" is fundamentally about change in organizations. Action research through intensive collaboration between researchers and practitioners is useful for scrutinizing factors in the change in question and for enhancing the relevance of academic research for practical application (Avison, Lau, Myers, & Nielsen, 1999; Coughlan & Coghlan, 2002). We conducted six action research projects with industry and government that aimed to use specific big data to design IISs in the automobile, transportation, healthcare, wellness, telecommunications, and IT industries; the six projects involved the analytics of real data produced by industry and government and interviews with researchers and practitioners who have expertise in IT and service management. The diversity among the six projects contributed to the gaining of multiple insights on data-based value creation. This paper demonstrates the utility of the nine factors through examples from the six projects and the 149 IIS cases analyzed in our study.

IISs with intensive data usage are becoming increasingly relevant in the modern data-rich economy and are expected to gain popularity across industries given the rapidly increasing quantities of data collected from objects and people. Our study is the first to investigate the unique mechanisms of data-based value creation in IISs. Our study contributes to the theory by presenting an empirically tested theoretical framework for describing data-based value creation and for using data effectively. The proposed nine-factor framework synthesizes the relevant literature on data usage and value creation in service. Researchers have previously investigated specific activities and resources relevant to this work by conducting studies on topics such as data collection (e.g., Gubbi, Buyya, Marusic, & Palaniswami, 2013), data analytics (e.g., Gandomi & Haider, 2015), and IT-mediated information delivery (e.g., Schumann, Wünderlich, & Wangenheim, 2012), which in turn largely determine how value is created from data. However, it is not well understood how different types of activities and resources work together to create value from data. "Using data to create value" is a truly *interdisciplinary* research topic (Ekbia et al., 2015; Lim, Kim et al., 2017; Ostrom et al., 2015; ur Rehman et al., 2016). The proposed nine-factor framework is grounded in and meaningfully integrates existing work. Our study also contributes to the practice as the proposed framework is useful in the analysis and design of data-based value creation; the motivation for our action research (i.e., the project request from industry and government) had a practical origin. Rather than exploring individual points on the data-to-value spectrum, our paper focuses on developing a simple yet comprehensive view that enables the full spectrum to be understood and managed.

The paper is organized as follows: In Section 2, we review the literature related to this study. In Section 3, we describe our research method. In Section 4, we propose the nine factors that characterize data-based value creation in IISs. In Sections 5 and 6, we demonstrate the utility of the proposed factors through their use in describing, analyzing, and designing the data-based value creation in specific IISs. Section 7 concludes the paper with a discussion of the limitations of the study and potential directions for future work.

2. Literature review

2.1. Studies on data use in service

The recent proliferation of data has resulted in various forms of service that create value through data use. For instance, prognostics and health management (PHM) services use data about the condition of sophisticated equipment to manage potential breakdowns and maximize availability for stakeholders (Lee, Kao, & Yang, 2014). Using smart bands or other wearable devices, fitness tracking services collect data on daily living, such as behavior, bio-signal, and food menu data, to help users achieve specific fitness-related outcomes, such as walking 10,000 steps (Takacs et al., 2014). Using attachable sensor devices, a heartbeat monitoring service collects heartbeat data during customers' daily lives and analyzes the data to deliver diagnostic and prognostic information to them. Building energy management services (BEMSs) determine the energy consumption patterns of a building from collected data, such as the amounts of electricity and gas used, according to external conditions (e.g., temperature, amount of rainfall, and solar insolation) to manage energy consumption (Dounis & Caraiscos, 2009).

Customer data (i.e., data produced by customers) are beneficial for understanding customers and thus are useful for enhancing assessments of market sentiment (Boyd & Crawford, 2011). Analysis of customer data can establish the reasons for certain customer decisions and lead to a better understanding of their behavior (Lim et al., 2015). Enhancing the extent to which customers are understood makes improved service offerings possible. Customer data provide firms with many opportunities, including value diversification, the generation of additional revenue, increased customer loyalty, the discovery of new markets (Saarijärvi, Grönroos, & Kuusela, 2014), the creation of information content, and the design of service concepts (Lim, Kim et al., 2017). Moreover, the relationship between a firm and its customers can benefit from the use of customer data (Payne & Frow, 2005), and this concept potentially applies as well to the relationship between a firm and society (Kumar et al., 2013). Service providers also generate data that are useful for service improvement. Hospitals collect operational data, which are analyzed to assess their healthcare service quality and from which they extract useful information to enable medical practitioners and hospital administrators to enhance the quality of their services (Yoo et al., 2014). Smart cities use data captured by sensors and cameras installed throughout the city to provide citizens with information about the weather, energy consumption, security, and other matters of interest (Hashem et al., 2016).

These studies have demonstrated that using data is key in understanding and attracting customers as well as for improving the activities of service providers. However, these studies mainly concerned the phenomenological benefits of data to service. There is limited research describing the mechanisms behind these benefits, although an articulation of the mechanisms is essential in using data and managing related IT to create value in service. Our objective is to address this research gap by identifying the key factors that determine the mechanisms. Identifying the key factors that describe a system is useful for its analysis and design and enables morphological analysis to be performed (Geum, Jeon, & Lee, 2016; Yoon & Park, 2005). Morphological analysis decomposes a system into several factors (or dimensions), uses the factors to analyze existing systems, and combines the factors to solve new problems (Ritchey, 1998); it has been frequently used in technology development and engineering design (Belaziz, Bouras, & Brun, 2000; Yoon & Park, 2005) and was recently applied in the service context (Geum et al., 2016).

Resources (e.g., a data collection system) and activities (e.g., data analysis) are necessary for the mechanisms that are responsible for creating value from IISs. Opresnik and Taisch (2015) discussed the ways in which services in the manufacturing industry rely on storing and analyzing data generated by customers to produce new information. Raghupathi and Raghupathi (2014) presented an architectural framework that can enable healthcare providers to utilize big data analytics, including data sources, data transformation, and data analytics applications. Atzori et al. (2010) identified the most important resources for the Internet of Things; these resources include sensing and communication technologies combined with a software layer or multiple sub-layers at the interface of these technologies with the application. A smart, connected product is defined as a product into which physical, smart connectivity resources are integrated to provide specific functions (Porter & Heppelmann, 2014). Lim and Maglio (2018) identified five dimensions of smart service systems, called the 5Cs (connection, collection, computation, and communications for co-creation), which may represent the key resources and activities of modern technology-based IISs.

All these studies have indicated the utility of factor identification in enabling basic understanding, analysis, and design of the system in question. Some of the existing studies may be used as a basis for analysis and design in the context of data-based value creation in IISs. However, their applicability is limited because they do not focus on this context. Moreover, a comprehensive framework that shows how different factors operate together in IISs to create value by using data has not yet been reported. Such a framework would be a truly interdisciplinary research topic, requiring integration across the range from data to value. Our focus is on the unique characteristics of data-based value creation in IISs, with the aim of developing a comprehensive framework that organizes and aligns different factors to analyze and design the overall spectrum of value creation.

2.2. Studies on value creation in service

Value creation based on data in IISs requires an understanding of value creation in service. Firms enable customers to create their own value based on what the firms can offer (Normann & Ramirez, 1993), and these offerings enable customers to combine their competences with resources available from the firm (Prahalad & Ramaswamy, 2000). Therefore, customers and firms jointly create value (Prahalad & Ramaswamy, 2002; Merrilees, Miller, & Yakimova, 2017), or, speaking more generally, this phenomenon occurs among multiple actors (Pinho, Beirao, Patrício, & Fisk, 2014; Vargo & Lusch, 2016). "The roles of producers and consumers are not distinct, meaning that value is always co-created, jointly and reciprocally, in interactions among providers and beneficiaries through the integration of resources and application of competences" (Vargo, Maglio, & Akaka, 2008, p. 146).

Vargo and Lusch (2004) used their framework of service-dominant (S-D) logic to propose a comprehensive foundation for the concept of value co-creation. A process-based conceptual framework was developed by Payne et al. (2008) to understand and manage a detailed mechanism of value co-creation in the context of S-D logic. Their framework involves customer, encounter, and supplier processes. A customer process is defined as "a series of activities performed by the customer to achieve a particular goal." Encounter processes are used to co-create customer value based on the ongoing interaction between a customer and a supplier. A supplier that aims to improve its competitiveness would need to influence the focal customer processes to enable customers to use available resources efficiently and effectively (Payne, Storbacka, & Frow, 2008). Other important studies have presented theoretical and empirical discussions of the concepts, utilities, and mechanisms of value co-creation in the multidisciplinary contexts of service management, including marketing, information systems, innovation, design, and engineering (Galvagno & Dalli, 2014; Gummesson & Mele, 2010; Lusch & Nambisan, 2015; Maglio & Spohrer, 2008; Ng, Parry, Smith, Maull, & Briscoe, 2012; Smith, Maull, & Ng, 2014; Vargo & Lusch, 2016).

When presenting the mechanism of value creation for customers, some studies, excepting those on S-D logic, highlight the significance of the concept of a customer process. The job-to-be-done (JTBD) theory (Christensen, Anthony, Berstell, & Nitterhouse, 2007; Ulwick, 2005) describes that customers are concerned with job activities, such as saving, farming, driving, dating, and doing business, and use various goods and services to conduct these activities. A job can be defined as "the fundamental problem that a customer needs to resolve in a given situation" (Christensen et al., 2007). All jobs involve processes (Bettencourt & Ulwick, 2008), and devising innovative goods and services requires the understanding and management of customer processes to accomplish jobs (Bettencourt, 2010; Lim, Kim, Hong, & Park, 2012; Lim, Choi, Lim, & Kim, 2017). Bettencourt et al. (2014) combined the JTBD theory with S-D logic to describe the use of the concept of customer process to co-create value between customers and firms. The importance of maintaining customer focus when creating value was emphasized in all the aforementioned studies. Collectively, these studies suggest that the customer-oriented thinking that entails escaping from known goods or service concepts extends the search space for discovering new and innovative customer solutions. In this regard, Heinonen et al. (2010) argued that obtaining a customer-dominant logic that focuses on the customer's own context (the customer process in our study) is necessary.

On the basis of these studies, we may describe data-based value creation in IISs as follows. Customers engage in specific processes to achieve their goals (Bettencourt & Ulwick, 2008), and firms offer specific value propositions (i.e., IISs) to help customers; firms interact with customers, collect data from various sources related to customers and service operations (Lim et al., 2012), and deliver information to customers (Lim & Kim, 2014); firms perform analytics processes to transform data into useful information (George, Haas, & Pentland, 2014); customers use this information in their value creation processes (Saarijärvi et al., 2014). Value is not created until customers (i.e., information users) actually use the received information for a specific purpose. In other words, value is created in the use of the information (Heinonen et al., 2010; Vargo & Lusch, 2004) by applying the information within the process. This literature-based description should be further extended to facilitate data-based value creation in IISs. We aimed to extend our finding from the literature significantly by conducting action research (Avison et al., 1999) consisting of six projects with industry and government that focused on the use of big data for IISs and by analyzing 149 relevant service cases.

3. Research method

The objective of this study was to develop an overall understanding of the factors that characterize data-based value creation. We accomplished this objective by combining action research consisting of six projects with an analysis of 149 cases. Action research is "an orientation to knowledge creation that arises in a context of practice and requires researchers to work with practitioners" (Huang, 2010). This specific research method "is unique in the way it associates research and practice, so research informs practice and practice informs research synergistically" (Avison et al., 1999). Our research objective was achievable using action research because (1) action research involves introducing change into organizations (Shani & Pasmore, 1985), which was the main goal of our study (i.e., using data to create or enhance value); (2) action research aims to develop a holistic understanding (Coughlan & Coghlan, 2002), and our research investigated the complete spectrum of data usage for creating value; (3) the concept of using big data in value creation originated from rapidly evolving practice, and the purpose of our research was to closely examine practice by presenting practitioners with specific actionable knowledge; and (4) action research combined with design science research (Hevner, March, Park, & Ram, 2004) can be used to design an artifact based on theory (Lüftenegger, Comuzzi, & Grefen, 2017), and the purpose of our study was to design a framework that describes data-based value creation in IISs.

To achieve such a research objective, researchers in academia are required to participate actively in real-world activities. We agree with Huang (2010) that legitimate understanding becomes possible only by taking action to ensure close observation. Action research has two goals: to solve a problem and to contribute to science (Coughlan & Coghlan, 2002). Our group has conducted a number of industrial and governmental service design projects to create value in IISs by using big data (i.e., the first goal of action research) and to identify the factors related to data usage by learning during the service design processes and via review after the processes (i.e., the second goal). The results of this work were obtained primarily from the six projects listed in Table 1. In practice, studies that involve action research are embedded in specific contexts. Therefore, clearly specifying the problem setting is crucial in action research to indicate the contextual aspects of a study and to discuss the extent to which the research question can be transferred (Mathiassen, Chiasson, & Germonprez, 2012). Action research requires researchers in academia to involve themselves deeply in the practical problems of the clients that the research intends to address. Action research projects cannot simply be selected in a manner similar to that of case studies; instead, these projects emerge naturally based on an agreement between the researcher and the client to solve a problem that reflects an industrial demand (Lüftenegger et al., 2017). Hence, we provide the organizational context for collaboration (Table 1) to explain the appropriateness of the research question to naturally emerging projects.

Project 1, which involves the design of a car infotainment service, concerns the use of data from private vehicles. Projects 2 and 5, which involve driving safety enhancement and eco-driving support service design, are concerned with data produced by commercial vehicles (e.g., buses, taxis, or trucks). Projects 3 and 6 are concerned with the design of a healthcare and student wellness enhancement service based on the use of personal health-related data. Project 4 entails the design of a data platform service that can create effective information with any commercially usable data. For further information on these projects, see Lim et al. (2015) for Projects 1 and 2; Lim and Kim (2015) for Project 4; Kim et al. (2017) for Project 5; and Lim, Kim et al. (2017) for Projects 1, 2, 3, and 6.

Some of the authors performed practical roles by actively participating in each of the six design projects. Each author was assigned a significant role in the empirical research data collection process for the current work. In this work, "empirical research data" refers to information related to the development and operations of IISs (e.g., the characteristics of big data in a project, data collection methods, data analytics processes, and service design processes conducted to create value), expert opinions concerning particular factors, and the architecture of the services designed in a project. The empirical research data from Projects 1–6 (i.e., the data for the current work) differ from the data used within the project (i.e., the data for an IIS).

Action research consists of the steps of problem diagnosis (preliminary step); data collection, data analysis, action planning, action implementation, and action evaluation (main steps); and reflective learning (follow-up step) (Avison et al., 1999; Coughlan & Coghlan, 2002). In each project, the service design process agreed with the main action research steps and was planned based on the new service development literature (Goldstein, Johnston, Duffy, & Rao, 2002; Johnson, Menor, Roth, & Chase, 2000) after diagnosing the problem based on discussions with practitioners. Our interpretation of the results during and after the projects corresponds to the reflective learning step. All the projects entailed monitoring, evaluation (by both researchers and practitioners), and re-execution of these steps to ensure that the action research was valid (Avison, Baskerville, & Myers, 2001; Coughlan & Coghlan, 2002) (e.g., Project 2 entailed analyzing sample data, identifying issues pertaining to data quality, requesting data from the client after specifying the data requirements, and analyzing quality data). This approach enabled us to obtain practical and theoretical insights into the factors related to the use of data for value creation. The six design projects focused on the specific beneficiaries of data usage as the main targets for value creation, namely drivers (Project 1), commercial vehicle drivers and transportation companies (Projects 2 and 5), the government and citizens (Project 3), any company that requires data analytics capability (Project 4), and students (Project 6). In summary, data usage in Projects 1–6 occurred in various contexts, and the diversity of these projects provided varied insights into the multi-factor nature of data-based value creation in IISs.

More specifically, in Project 1, we analyzed existing cases of data usage in the automobile industry; engaged in discussions with company managers and vehicle specialists; performed the necessary literature review; analyzed actual big data on driving and vehicle conditions; determined the most important considerations when using vehicle data to create value for stakeholders (e.g., engineers, drivers, and customer service managers); determined the requirements to develop and operate car infotainment services, such as the required data quality, data analytics capability, and related partnerships; and identified problems ranging from data collection to value creation in the industry. We subsequently identified the key factors related to car infotainment services, such as the device used for vehicle data collection, driving data, vehicle condition data, and information delivery channel, and used these factors to design services for car infotainment. Similarly in

Table 1
Six projects on the use of data to design information-intensive services.

Project	Brief description
Project 1 on the car infotainment service design through big data analytics (October 2011–June 2012)	The project designed car infotainment services with an automobile manufacturer, based on analysis of 7.6 million trip data points from 18,943 vehicles (vehicle driving data) and 3662 cases of warning code occurrences (vehicle condition data). The automobile manufacturer collected vehicle driving and condition data and was interested in developing services for customers using the data.
Project 2 on the driving safety enhancement service design through big data analytics (April 2013–May 2014)	The project designed driving safety enhancement services for commercial drivers with a government organization, based on analysis of operations data from commercial vehicles (278 buses, 46 taxis, and 931 trucks) and accident records of commercial vehicle drivers (4289 bus, 1550 taxi, and 490 truck drivers). The organization is concerned with driving safety of commercial vehicle drivers and had collected the data to develop and operate services to manage the drivers and transportation companies.
Project 3 on the health care and insurance service design through expert interviews (April 2014–October 2014)	The project designed health care and management services for health-related stakeholders with a government organization, based on interviews with 34 experts such as doctors, public health scientists, managers, and executives in the industry, as well as government employees. The organization collected various types of health-related data, including insurance, diagnosis, treatment, and medical examination data, and aimed to design service concepts that can serve as bases for the innovation of services in the health industry.
Project 4 on the data platform service design through workshops with company managers and executives (June 2012–December 2012)	The project designed a data platform service that facilitates data and information exchange among various players (e.g., data provider, administrator, analyst, information deliverer, and consumer) with a telecommunications company. The company aimed to develop new innovative service business models that use its existing IT resources. This project was conducted through design and evaluation workshops among researchers, managers, and executives.
Project 5 on the eco-driving support service design through data analytics (June 2014–October 2015)	The project designed eco-driving support services for bus drivers with the same organization of Project 2, based on analysis of bus operations and fuel consumption data collected from 33 bus drivers. The organization is also concerned with enhancing fuel-efficiency of commercial vehicle drivers and aimed to use their data for the eco-driving service development and operations management.
Project 6 on the student wellness enhancement service design through data analytics (January 2015–December 2015)	The project designed a smart wellness service for college students with an IT company and a student counseling center at a university, based on analysis of daily behavior data from 47 students. The IT company had developed a platform to manage and analyze big data and aimed to design services that measure daily wellness indices of specific groups of people, such as workers, children, and students, with their daily behavior data such as daily sleep time, daily diet records, and walking steps collected through smartphones and activity trackers.

Projects 2–6, we identified the factors associated with data-based value creation for a particular IIS. Furthermore, we used a specific set of factors to design the services in each project.

The findings from the six projects are situation-specific and thus are difficult to generalize (e.g., Projects 2 and 5 focus on IISs in transportation). This condition prompted us to conduct a cross-project analysis to seek a *sense of generality* by searching for characteristics that are similar and ones that are different. The empirical research data from Projects 1–6 were integrated and analyzed based on the following research question: "What are the factors that are responsible for and with which value can be created in IISs in the context of intensive data usage?" The cross-project analysis was mainly intended to identify descriptive knowledge applicable to many design cases (Gregor & Hevner, 2013). Our efforts proceeded toward theoretical generalizations, and we attempted to compile the knowledge gained through the course of the six design projects (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). We were primarily concerned with producing a concise list of factors that encompasses the learning points we collectively garnered from the six projects. In this way, 12 factors were initially identified. Subsequently, three of the authors evaluated whether the 12 factors covered all six projects and vice versa and then made appropriate modifications (e.g., combining, dividing, renaming). These authors made the primary determination of the extent to which the factors were applicable to the projects in which they did not participate.

Nonetheless, meeting the generality criterion for theory-generating research was not straightforward because each project depended fundamentally on its specific context (Ketokivi & Choi, 2014). Thus, to extend our view beyond Projects 1–6, which focused on specific contexts, we also analyzed data usage in 149 IIS cases documented in the literature, reports, and books, including services such as PHM (Lee et al., 2014), fitness tracking (Takacs et al., 2014), vehicle fleet management (Volvo, 2009), screen golf training (Jung, Park, Kang, Lee, & Hahn, 2010), and building energy management (Dounis & Caraiscos, 2009). We facilitated a structured analysis of the 149 cases by organizing the case information into a database. The database provides detailed information of each case, including the industry field, service provider, data that were used, information derived from data analytics, information users (i.e., customers), and information delivery channel. Although the entire content of the database is not presented in this paper because of space constraints, Table 2 summarizes the distribution information for the 149 cases by industry based on the International Standard Industry Code (United Nations, 2008).

More specifically, we tried to describe the whole spectrum of data-based value creation in 149 IIS cases using the factors (Section 4) and categorized them based on combinations of two or three factors (Section 5). The case analysis method can effectively test the ability of a theory to describe complex phenomena or systems (Ketokivi & Choi, 2014). This analysis was beneficial for assessing the ability of the initial set of factors to describe data-based value creation in the IISs. This refinement process also incorporated existing theories related to the multi-factor nature of IISs (e.g., studies reviewed in Section 2) as well as the factors related to IT management (e.g., Apte et al., 1997; Braganza,

Table 2
Distribution of the 149 information-intensive service cases analyzed.

Industry field	Frequency
Human health and social work activities	35
Manufacturing	29
Public administration and defence; compulsory social security	25
Information and communication	14
Electricity, gas, steam and air conditioning supply	13
Administrative and support service activities	6
Arts, entertainment and recreation	5
Professional, scientific and technical activities	5
Agriculture, forestry and fishing	5
Others	12

"Others" in the bottom row of Table 2 include "Transportation and storage," "Water supply; sewerage, waste management, and remediation activities," "Wholesale and retail trade; repair of motor vehicles and motorcycles," "Financial and insurance activities," "Real estate activities," "Education," and "Mining and quarrying."

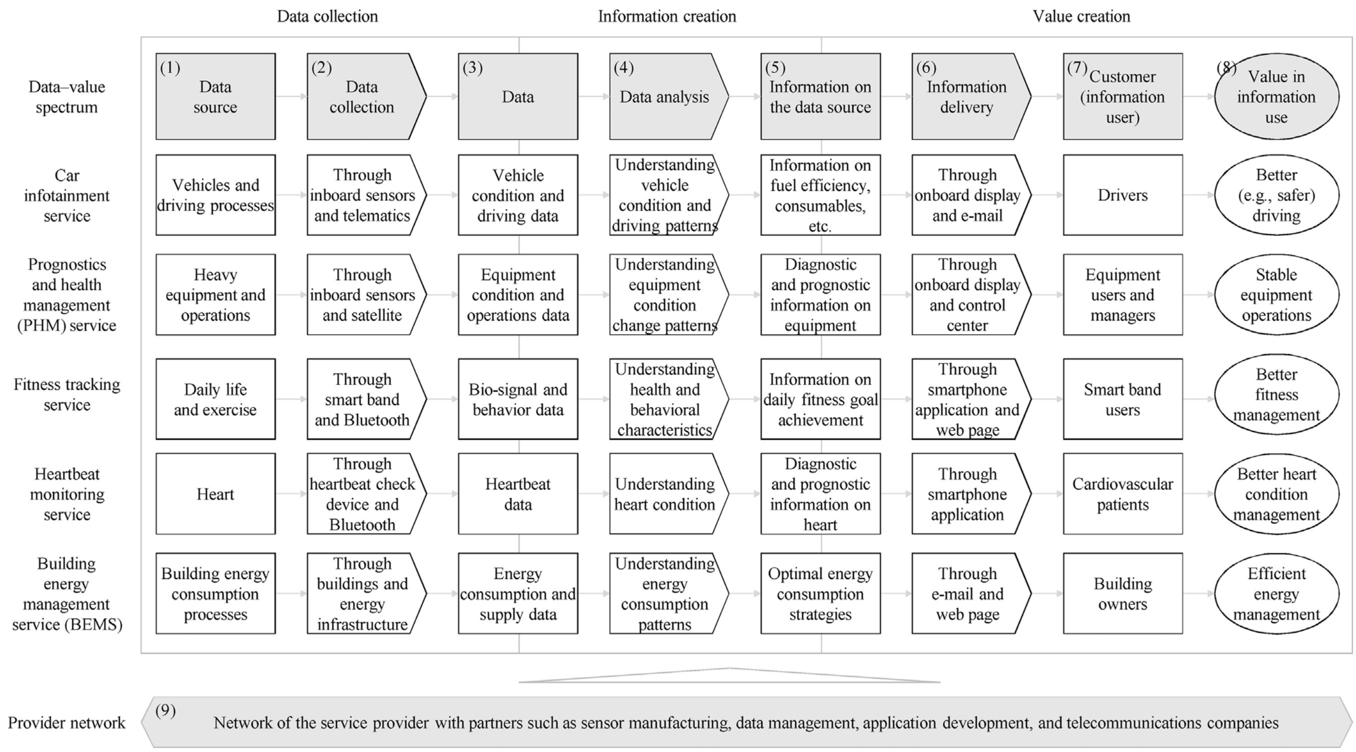


Fig. 2. Data–Value Chain: Nine-factor framework characterizing data-based value creation in information-intensive services.

2004). We iterated the refinement several times and arrived at the set of nine factors, which are discussed in the following sections. All 149 cases could be characterized effectively and efficiently by the nine factors.

Finally, we reviewed the information from the six projects and 149 cases by mapping them onto the set of nine factors to systematically organize our findings. This process essentially corresponded to the writing of this paper. In summary, the research outcome documented in this paper reflects insights from the analysis of actual big data in industry and government, analysis of existing IIS cases in multiple industries, interviews with experts and practitioners who have extensive experience related to IT and service management, design of information content for stakeholders using data, and design and evaluation of new IIS concepts from a value perspective. The complementary datasets of the six action research projects and 149 IIS cases were useful in identifying, testing, and refining the factors that characterize data-based value creation in IISs.

4. Factors characterizing data-based value creation in information-intensive services

The terms "data" and "information" have often been used interchangeably. For IISs, we distinguish data from information based on the data–information–knowledge–wisdom hierarchy (Braganza, 2004): Data are raw materials, the ingredients of information, and information is the outcome of data analysis, used for a specific purpose. Most traditional IT-based service concepts, such as technology-mediated service (Schumann et al., 2012) and mobile service (Niemelä, 2006), emphasize efficient *delivery* of information to customers. By contrast, IISs should also consider *creating* information that helps people achieve their goals and *collecting* the data needed to create useful information (Lim & Kim, 2014). Nonetheless, information delivery remains important in IISs as it affects the information user's convenience. From this perspective, data-based value creation in IISs concerns the whole spectrum from data collection and information creation to information delivery.

Fig. 2 shows a theoretical framework describing data-based value creation in IISs, named the "Data–Value Chain." This framework identifies the activities (pentagonal boxes), resources (rectangular boxes), and players (hexagonal box at the bottom) required for creating value (round box) through IISs. The top row (shaded) illustrates the full spectrum from data source to value. The other rows present the examples mentioned in Section 2.1. The bottom row (shaded) indicates the provider network, which includes the service provider and partners. As shown in the Data–Value Chain, data-based value creation in an IIS is divided into four areas: (i) data collection, (ii) information creation, (iii) value creation, and (iv) distribution through the provider network.

These areas are further divided into nine factors (indicated by the shaded shapes): (1) data source, (2) data collection, (3) data, (4) data analysis, (5) information on the data source, (6) information delivery, (7) customer (information user), (8) value in information use, and (9) provider network. These nine factors embrace the key areas of IIS analysis and design: what to deliver (5); why (8); to whom (7); how to produce it (1–4); how, when, and where to deliver it (6); and who to create and deliver it (9). The use and management of data in IISs should consider these areas to facilitate value creation with data. We now describe each factor in turn. Each of the following paragraphs explains the variations within a factor and ends with a proposition regarding data-based value creation in IISs. The variations were identified mainly from the analysis of the 149 IIS cases in Table 2, and the propositions were derived mainly from Projects 1–6 in Table 1.

Data sources (factor 1) of IISs include specific objects, such as vehicles; facilities, such as a city infrastructure; management activities, such as city administration; and customers, such as drivers and citizens. This factor can be classified according to the main source of data, which may be people or objects. Fitness tracking services mainly use bio-signals and behavioral data from users of smart devices, whereas PHM services collect data about the condition of equipment. From the perspective of the data source, we view recent attention to big data proliferation as an extension of data sources. One of the main distinctions between traditional and recent data uses is the source of data (i.e., engineering systems versus human systems). This factor is useful for the analysis and design of data-based value creation in IISs because knowing where data are to be collected is directly connected to the purpose for their use (i.e., purpose of the service).

The methods of *data collection* (factor 2) in IISs include using sensors, recording logs of IT system users, and crowdsourcing opinion data. This factor can be classified according to the level of human involvement, which may be physical sensing or social sensing. Here, physical sensing refers to a process enabled by or conducted through physical sensors, and social sensing includes any type of sensing enabled by or conducted through people without using physical sensors. Examples of social sensing include data collection from social network services (SNSs), surveys, interviews, user queries, documents, and manual recording of specific data. Car infotainment and PHM services collect data from engineering systems through physical sensing, whereas fitness tracking services involve physical sensing of human bodies and manual input of data about daily living (e.g., food menu data) by users. This factor is useful for the analysis and design of data-based value creation in IISs because the method for collecting data is highly related to service efficiency.

Data (factor 3) of IISs include traces of the condition of engineering systems, event logs of business systems, health and behavioral records of people, and bio-signals of animals. This factor can be classified according to the focus of the data, which may be health (condition) or behaviors (operations). PHM services mainly use equipment condition data, whereas BEMSs mainly use building energy consumption (i.e., operational) data. Car infotainment services use both vehicle condition and operational data intensively. This factor is useful for analysis and design of data-based value creation in IISs because the data content is directly connected to the scope and potential of the service.

The methods of *data analysis* (factor 4) in IISs include using specific algorithms pre-installed on servers and expert knowledge. This factor can be classified according to the level of human involvement, which may either be fully automated or involve humans. In most PHM services, data analysis is fully automated with PHM algorithms (Schwabacher & Goebel, 2007). In some heartbeat monitoring services, by contrast, medical specialists are often involved in data analysis. This kind of human involvement is common in health-related IISs because such services concern human health. Stock market analytics also requires a high level of human involvement for final decision making. According to Barnaghi et al. (2013) and based on the authors' experience, data analysis activity often requires several preliminary tasks, such as data cleaning, anonymization, aggregation, integration, and storage. This factor is useful for the analysis and design of data-based value creation in IISs because the methods that are used to analyze the collected data influence the quality of service.

Information (factor 5) created from data analysis reveals interesting facts about the original data source. For example, data about the condition of equipment, infrastructure, and facilities are used to create information that indicates the states of the engineering systems. Data from people are used to produce information on the behavior and health of the data sources. Furthermore, information created with the data generated by a company department (e.g., communication records and documents) or a group of people (e.g., SNS data) indicates specific characteristics of these social systems. The form of information includes descriptive statistics, comparisons with other customers, and guidelines for specific task improvement (e.g., driving). This factor can be classified according to its level, which may be descriptive, predictive, or prescriptive (Delen & Demirkan, 2013). Descriptive information shows "what happened and/or what is happening." Predictive information shows "what will happen and/or why it will happen." Prescriptive information shows "what I should do and/or why I should do it." Each item builds on the preceding one; for example, to identify predictive information, an IIS provider must have descriptive information. Most existing fitness tracking services provide descriptive information on the health and behavior of customers. By contrast, PHM services provide predictive information to prevent unexpected breakdowns. BEMS providers identify prescriptive information on optimal energy consumption for cost savings. This factor is useful for the analysis and design of data-based value creation in IISs because creation of value from data is directly connected to the value and attractiveness of the service.

The methods of *information delivery* (factor 6) in IISs include e-mail, phone calls, smartphone applications, and onboard displays in vehicles. As with data analysis, the level of human involvement is an essential attribute of information delivery in IISs. In most fitness tracking services, information delivery is fully automated based on technology constructed beforehand. In some heartbeat monitoring services, by contrast, medical specialists deliver information. This factor is useful for the analysis and design of data-based value creation in IISs because selecting an appropriate method for information delivery is highly relevant to the efficiency and acceptability of the service.

Customers (information users) (factor 7) of IISs include drivers who use car infotainment services, parents who use baby monitoring services, and citizens and local organizations that use IISs in smart cities. This factor can be classified according to the level of the main users, which may be individual or organizational. The former represents B2C services, whereas the latter exemplifies B2B services. The main information users of fitness tracking services are individual smart device users, whereas the main users of BEMSs are affiliated with organizations. The main users of PHM services include both individual equipment users and managers of equipment-using companies. This factor is useful for the analysis and design of data-based value creation in IISs because it represents the service target.

Examples of *value* (factor 8) of IISs include evidence-based health management, improvement of the operational processes of certain service systems, and prevention of potential user problems. Note that value is not created until users actually use the received information for a specific purpose. In other words, value is created *in information use* (Lusch & Nambisan, 2015; Vargo & Lusch, 2004). For example, driving safety can be improved when information promoting safe driving is used by drivers, and health can be improved when health-related advisory information is used. This factor can be classified according to the main objective of information use, which may be to prevent undesirable outcomes or achieve desirable outcomes related to the data source. PHM services mainly aim to prevent unexpected stoppages of equipment operations, whereas the main goal of fitness tracking services is to support customers in achieving their desired outcomes, such as walking 10,000 steps or eating less than 2000 kcal. This factor is useful for the analysis and design of data-based value creation in IISs because it represents the mission of a service and its value proposition.

The *provider network* (factor 9) behind IISs consists of the main service provider (which directly interacts with customers) and its partners, such as companies engaged in sensor manufacturing, data management, and analytics. Because the data and information can be digitized into bits unlike other types of deliverables in business, outsourcing is very common in IIS provision (Karmarkar & Apte, 2007). This factor can be classified according to whether the main service provider involves a goods-oriented network or a service-oriented network. Many of the PHM service providers are equipment manufacturers, whereas many of the BEMS providers are service-oriented (e.g., telecommunications companies). This factor is useful for the analysis and design of data-based value creation in IISs because it represents the capability and potential of the service.

On the basis of the literature reviewed in Section 2.2, Fig. 3 further shows how the nine factors interact to create value in IISs by mapping them onto the conceptual framework for value co-creation (Payne et al., 2008). The data-based value co-creation mechanism of IISs involves the customer, interaction (encounter), and provider (supplier) processes. (1) The customer and provider processes involve the data sources of both the provider and the customer, such as objects and human bodies. (2) Data are collected through the interaction process, which involves physical and social sensing of the data sources. (3) The collected and integrated data indicate human health and behavior or the condition of an object and operations. (4) Data analytics is conducted as part of the

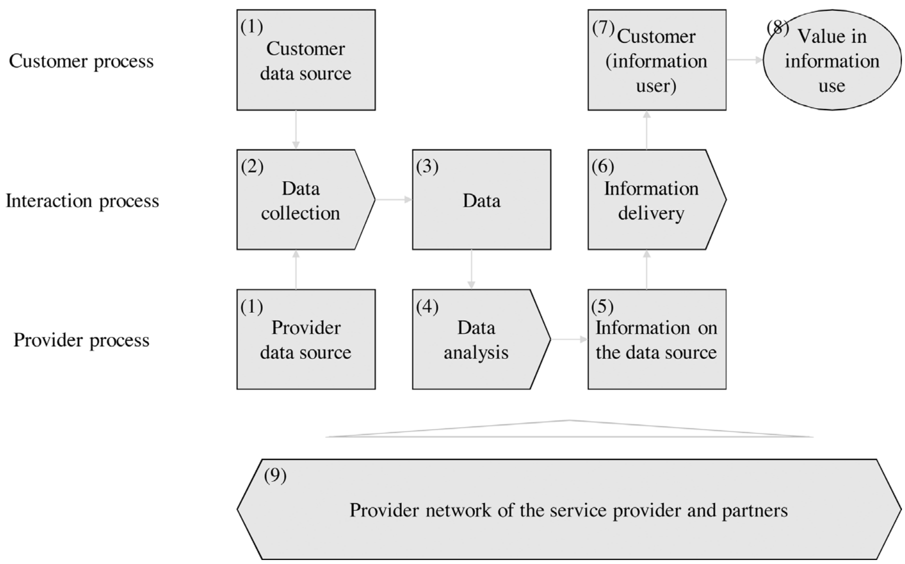


Fig. 3. Data-based value co-creation mechanism of information-intensive services.

provider process and is often invisible to the customers. (5) The results of the data analytics provide descriptive, predictive, or prescriptive information on the data source. (6) Information delivery involves interactions between the customer and provider. (7) Customers (information users) receive the information and (8) create value-in-use with the information about the data source. (9) The provider network, consisting of the service provider and its partners, is responsible for the management of these activities and resources.

Researchers have intensively discussed the notion of value co-creation in the context of IT use for service (e.g., Barrett et al., 2015; Maglio, 2015; Nambisan, 2013). However, except for the works of Saarijärvi et al. (2014) and Lim, Kim et al. (2017), our literature review revealed a surprising lack of research directed at providing a framework to help organizations describe and manage data-based value co-creation, despite its significance in the modern data-rich economy. The framework shown in Fig. 3 illustrates the interaction and contribution of customers and service providers in co-creating value with data. In addition, only a few papers (e.g., Payne et al., 2008; Ulaga & Reinartz, 2011) discuss how organizations can *operationalize* value co-creation with customers. The fifth axiom of S-D logic states that "value co-creation is coordinated through actor-generated institutions and institutional arrangements" (Vargo & Lusch, 2016). Thus, S-D logic indicates the necessity of conducting research into operationalizing value co-creation in service settings. We believe one barrier to operationalizing value co-creation is a limited understanding of the factors and mechanisms involved in the operations. The framework shown in Fig. 3 illustrates the activities and resources that should be considered and managed when operationalizing value co-creation in the context of IISs with intensive data use.

5. Using the nine factors to describe and analyze information-intensive services

As described, data-based value creation in IISs can be described effectively using a set of nine factors. Comparison of different IIS cases is made easy and efficient with these factors. For example, the car infotainment service and fitness tracking service are similar in terms of customer type (i.e., individual user) but different in terms of data sources (Fig. 2). Fig. 4 presents a taxonomy of IISs according to the nine factors, summarizing our explanation given in the previous section. The taxonomy was developed based on the six projects and 149 IIS cases introduced in Section 3. The taxonomy represents the multi-factor nature of data-based value creation in IISs and the various forms an IIS can take. In the right part, Fig. 4 also shows examples of IIS configurations. IIS design can be facilitated by identifying the options instantiated for each factor and by configuring these options. In other words, the nine factors could be considered the dimensions that constitute a *design space* for IISs, and the taxonomy exemplifies the design space. Note that the examples in Fig. 4 represent only the specific cases we analyzed (e.g., the car infotainment services of several automobile manufacturers studied by the authors between 2011 and 2015); they may have different configurations in other contexts or in the future.

Categorization of services has contributed to describing and understanding services (e.g., Lovelock, 1983), gaining managerial insights about services (e.g., Frei, 2006), and identifying archetypes (i.e., design models) of services for service design (e.g., Glushko, 2010). Identifying key factors related to a given service is a prerequisite for service categorization because factors serve as dimensions for categorization. In this respect, an effective approach for analyzing and improving IT use cases in IISs is to search for similarities and differences between cases. Fig. 5 shows some categorizations of IISs given various combinations of the nine factors. Fig. 5(a) categorizes IIS cases based on the types of data source (factor 1) and data (factor 3) and may be used for examining the utility of certain types of data. Fig. 5(b) demonstrates that organizing IISs according to the type of information (factor 5) and user (factor 7) is also useful.

As shown in Figs. 2–4, each of the nine factors provides a lens for viewing the value creation methods of IISs, and taken together, they are useful for describing and creating differentiation among IISs. Thus, the set of factors can be used as a tool for identifying IIS opportunities. For example, heartbeat monitoring services are differentiated by the extent to which medical specialists are involved in information creation and delivery. One provider may only offer a device and an application for monitoring, whereas another may provide professional diagnosis. Human involvement, which is related to service authority, is also effective in terms of providing emotional care but costs more. In short, involving humans in the activity factors in IISs (i.e., data collection, analysis, and information delivery) is an effective strategy to address the experiential aspect of IISs. Although it is not shown in the taxonomy in Fig. 4, the question of whether to outsource an activity of an IIS is universally important in the three activity factors because the activities may require diverse capabilities. For example, wearable device manufacturers can seek differentiation by partnering with hospitals and integrating various types of healthcare-related data from the hospitals. Likewise, data from smart cars could be integrated with data from smart homes.

Key factors	Options	
(1) Data source	People	Objects
(2) Data collection	Physical sensing	Social sensing
(3) Data	Data about health or condition	Data about behaviors or operations
(4) Data analysis	Automated analysis	Human-involved analysis
(5) Information on the data source	Descriptive level	Predictive or prescriptive level
(6) Information delivery	Automated delivery	Human-involved delivery
(7) Customer (information user)	Individual users (B2C)	Organizational users (B2B)
(8) Value in information use	To prevent undesirable outcomes related to the data source	To achieve desirable outcomes related to the data source
(9) Provider network	Goods-oriented network	Service-oriented network

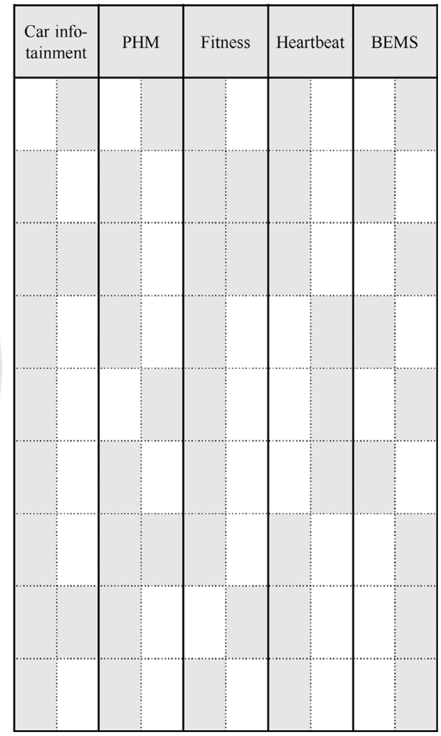
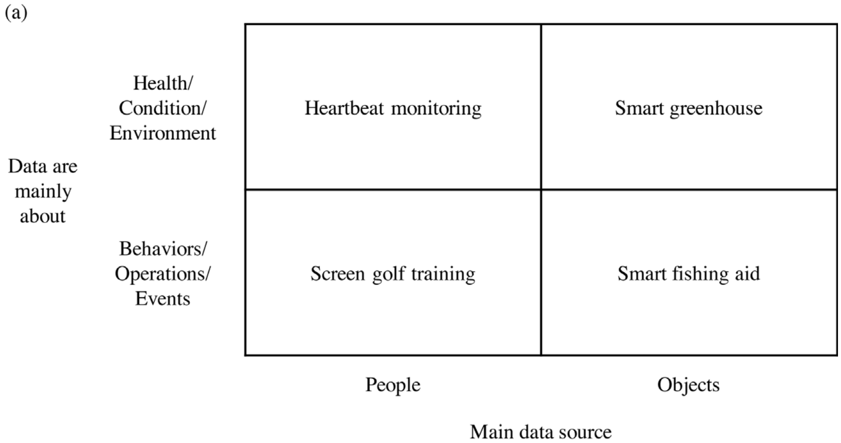


Fig. 4. Taxonomy of information-intensive services and examples of service configurations.

(a)



(b)

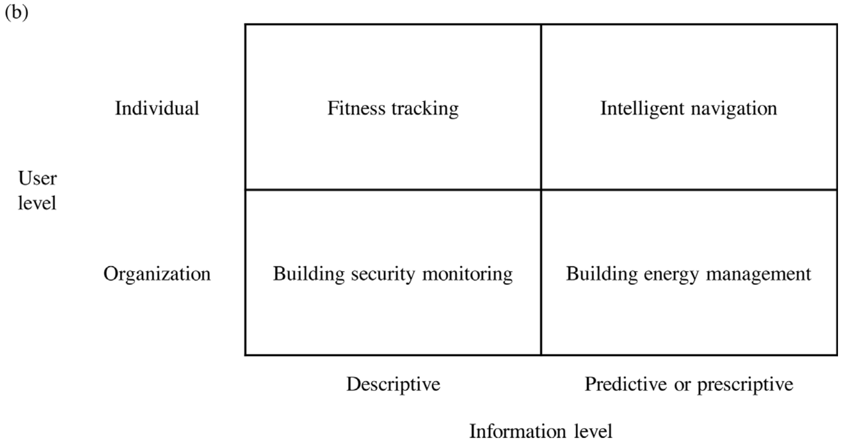


Fig. 5. Examples of the categorization of information-intensive service cases using the nine factors.

6. Using the nine factors to design information-intensive services

Service innovation through IT usage (Chuang & Lin, 2015; Lusch & Nambisan,2015) depends on new or improved service ideas, concepts, processes, business models, and more. Service design contributes to the creation of these (Patrício, Fisk, Falcão e Cunha, & Constantine, 2011). When any artifact is designed, understanding and drawing the *structure* of the design target is essential for bringing new ideas to users (Ulrich, 2011). This is important in IIS design but difficult because of the inherent fuzziness of service descriptions (Glushko, 2013), complexity of service systems (Lim & Maglio, 2018), and lack of understanding of IT usage for service (Nambisan, 2013); thus, studies on IIS design have investigated and visualized the structure of design targets (Lim & Kim, 2014; Patrício, Fisk, & e Cunha, 2008). Understanding the structure of a given IIS contributes to the materialization of ideas and identification of design considerations for full development of service and information systems.

The nine factors are useful for defining the structure of an IIS under design. Projects 1–6 used some of these factors as bases for IIS design. For example, in Project 3 (health-related IIS design case; see Table 1), the service designers defined the service to be designed in terms of which providers deliver the service to which customers using which data providers to provide which information via which delivery channels. Fig. 6 shows an example and provides a representation of a service designed in the project, named the "Local Health-nostics Service." This service involves the health insurance division of the Korean government and provides diagnostic and prognostic health information to local governments. The information for local governments (the customers) includes a disease map, local health statistics, the conditions of local medical institutions, patient distribution, and public health policy reviews. The data shown in the figure are categories of specific data fields. For example, the medical examination data include the data fields of insurance subscriber type, examination year, job code, and stomach cancer status. Structured service representations such as Fig. 6 are useful for designing data-based value creation in IISs as well as for facilitating communication among those involved in service design. The set of proposed factors can serve as a basis for such representations.

Similarly, Fig. 7 shows the main characteristics of the services designed in Project 1 (car infotainment service design case; see Table 1). For example, the driving safety enhancement service provides driving safety indices and ranking information on the onboard screen. This service requires a driving safety analysis algorithm as an information creation system and an insurance company as a partner. As shown in the figure, the proposed factors are useful for specifying the designed IISs.

In Project 4 (data platform service design case; see Table 1), 14 new service ideas were proposed and evaluated before focusing on the design of the data platform service. Some of the proposed factors were used as lenses for the evaluation of the new service ideas. The service designers evaluated these ideas with respect to the effectiveness of information, efficiency of information delivery system, efficiency of information creation system (i.e., data analysis system), and efficiency of partnership. Despite the simplicity of these criteria, they were highly effective in identifying the strengths and weaknesses of service ideas from the perspective of the transformation of data into information. Thus, the nine factors can also be applied in the development of evaluation criteria for designing valid IISs.

The proposed nine factors are related to those that were identified in existing studies of business model design (e.g., Johnson, 2010; Osterwalder & Pigneur, 2010). Taking the nine building blocks for business model design (Osterwalder & Pigneur, 2010) as an example, the value and information factors correspond to the value proposition block, the customer (information user) factor corresponds to the customer segments block, the information delivery factor corresponds to the channels block, the data collection and analysis factors correspond to the key activities block, the data source and data factors correspond to the key resources block, and, finally, the provider network factor corresponds to the key partnerships block. Thus, the proposed nine factors will complement existing knowledge for the design of business models in which data use is the key to value creation. In Fig. 8, we show the nine building blocks and the "Data–Value Design Canvas" for data-based value creation in an IIS to suggest a synergy with the Business

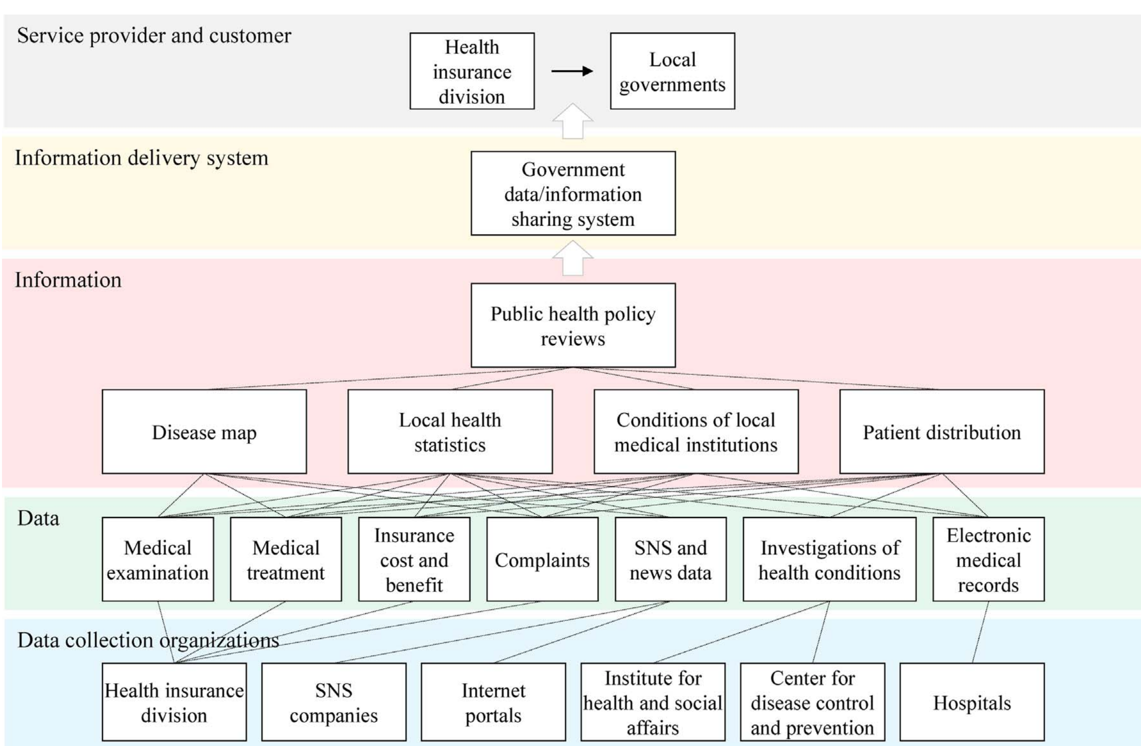


Fig. 6. Local Health-nostics Service, designed in Project 3.

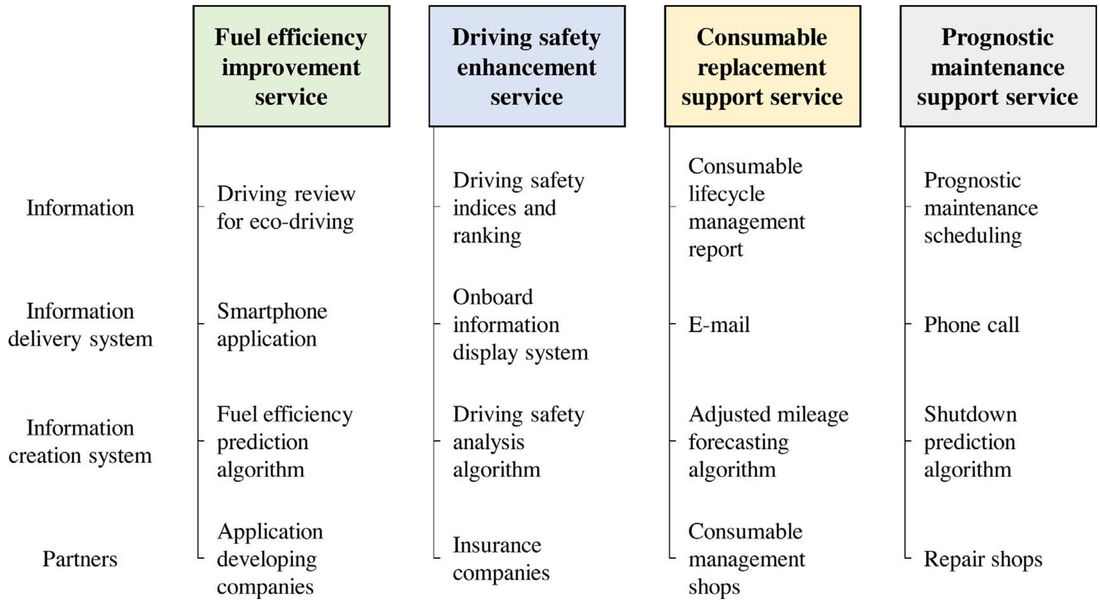


Fig. 7. Main characteristics of the four car infotainment services designed in Project 1.

Model Canvas (Osterwalder & Pigneur, 2010). An example in which the Data–Value Design Canvas is used is given in Fig. 9, which shows the Local Health-nostics Service on the canvas (a style of representation different from that in Fig. 6); the canvas was used in Project 3 for systematic service design and communications between the project participants. Similar to the use of the Business Model Canvas for IISs (Dijkman, Sprenkels, Peeters, & Janssen, 2015; Muhtaroglu, Demir, Obali, & Girgin, 2013), the set of nine factors could serve as a basis for applying a morphological analysis to the design of data-based value creation in IISs.

Figs. 2, 3, 4, and 8 can be used as basic tools for designing IISs. The Data–Value Chain (Fig. 2) suggests nine factors that should be considered when devising an IIS. Fig. 4 demonstrates the variety of design options available for an IIS. Figs. 3 and 8 can be used as templates for designing IISs. These tools enabled us to develop a multi-factor design approach to data-based value creation in IISs based on the proposed nine factors (Fig. 10). Although the tools were not available at the time, all of the design processes in Projects 1–6 followed the process shown in Fig. 10.

This approach can address several methodological challenges in the design of IISs or information systems. The mission of service or information system design is to devise a service capable of creating value or enhancing value creation. Thus, a prerequisite for designing new services or improving existing services is to gain a fundamental understanding of value creation mechanisms in the specific design context (Friedman, Borning, & Huldtgren, 2013; Lim & Kim, 2014). The first step and its associated tool in Fig. 10 address this problem. A service concept is a description of what needs to be done for the customer and how it can be done (Goldstein et al., 2002; Kim et al., 2012, 2016). Thus, designing service concepts requires an understanding of the factors that constitute the *what* and the *how* of service. A difficulty associated with service design is that the design space is wide and complex because the candidates for the *what* and the *how* are varied. The second step and its associated tool in Fig. 10 address this problem. Services are

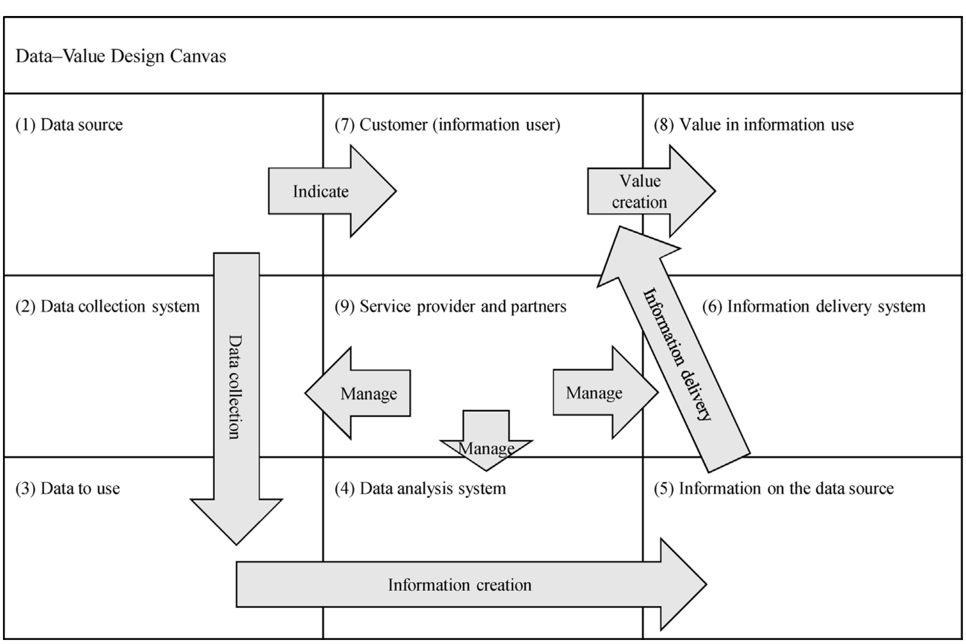


Fig. 8. Data–Value Design Canvas: Nine building blocks for data-based value creation in an IIS.

Local Health-nostics Service designed in Project 3		
(1) Data source • Citizens • Health-related organizations	(7) Customer (information user) • Local government employees	(8) Value in information use • Systematic management and enhancement of citizens' health levels
(2) Data collection system • National insurance system • Survey and visiting research • Text data crawling from Internet …	(9) Service provider and partners • Health insurance division • Institute for health and social affairs • Hospitals …	(6) Information delivery system • Government data and information sharing system
(3) Data to use • Medical examination • Medical treatment • Insurance cost and benefit …	(4) Data analysis system • Database integration system • Local health indicators • Algorithms for local health diagnostics and prognostics	(5) Information on the data source • Public health policy reviews • Disease map • Local health statistics …

Fig. 9. Local Health-nostics Service on the Data–Value Design Canvas.

complex (Maglio, Vargo, Caswell, & Spohrer, 2009) and fuzzy (Glushko, 2013). Hence, attempts to represent the IIS concept while designing the service can help people build and use mental models to better understand, describe, and analyze the service in question, thereby eventually contributing to the improvement of design outcomes (Lim & Kim, 2014). The representation of the IIS concept serves as the basis for obtaining an overview of the designed service to determine the relationships within the service. The third step and the associated tools in Fig. 10 address this problem.

As we have described, we consider the proposed nine factors to have methodological utility. We also recognize organizational utility in their ability to address the interdisciplinary nature of service design for using data to create value. Service design and data analytics projects require a cross-functional team with members from various functional units, including planning, design, engineering, IT, and marketing. In particular, the design of IISs should incorporate expertise in data analytics and service design (i.e., expertise across the spectrum on the Data–Value Chain; see Fig. 2). All of the design cases in Projects 1–6 involved various types of experts. For example, Project 1 was conducted by industrial engineering researchers, company managers with diverse backgrounds, and vehicle experts; Project 3 involved doctors, public health scientists, data scientists, IT experts, business experts, and government employees; and Project 4 was managed by IT, telecommunications, and business experts. The nine factors are expected to

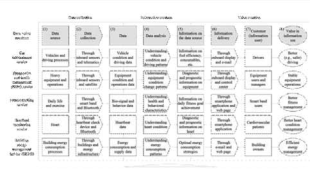
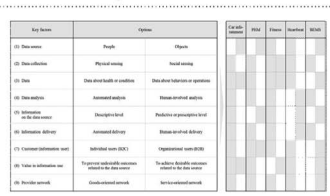
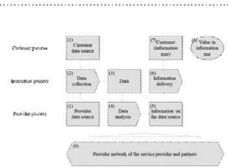
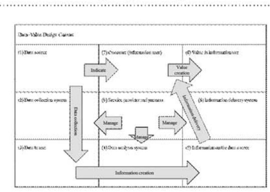
Design step	Design tool
1. Identify the key factors of the service in question	 Nine factors characterizing data-based value creation (Figure 2)
2. Identify multiple choices for service design (explore the design space)	 Taxonomy of data-based value creation (Figure 4)
3. Devise the service design templates and map services onto the templates	  Value co-creation mechanism (Figure 3) Design canvas (Figure 8)

Fig. 10. Multi-factor design approach for data-based value creation in IISs based on the proposed nine factors.

be useful in such interdisciplinary environments, ensuring an integrated design of complex IISs. These factors can be used to synthesize contributions from different fields across the spectrum on the Data–Value Chain and therefore allow the integrated design of the service idea, concept, and process. They can also be used to improve the dialogue between project participants because they support the development of collective reference points and shared language to create joint understanding. We have in fact observed that this in turn significantly improves communication, thereby ensuring effective and efficient IIS design for creating value with data. For example, by exploring the design space based on multiple factors and by representing the designed service concepts in a structured manner in Project 3 (Fig. 6), the service designers incorporated information gained from experts, citizens, existing cases, and the literature into several concepts and facilitated communication between them, the experts, and the project client (i.e., the government organization).

Various methods exist for IIS or information system design, such as Information Service Blueprint (Lim & Kim, 2014) and value sensitive design of information systems (Friedman et al., 2013). However, a service design method or approach that covers the full spectrum from data to value in IISs, despite its importance, has not yet been reported. We believe the approach illustrated in Fig. 10 can be used for future study of the design of IISs and information systems in this data-rich economy.

7. Concluding remarks

As we record increasing quantities of data on our behavior and health as well as from various objects, IISs are expected to become increasingly important (Karmarkar & Apte, 2007; Lim & Kim,2014). This paper proposes nine factors that characterize IISs. These factors show that IISs entail the collection of data from certain sources, creation of useful information on the data sources using data analysis, and delivery of information to users to help them create value. The nine factors are useful for describing how the provider and customer can co-create value through data and information exchange, as well as for describing and differentiating among IISs. In short, the nine factors serve as lenses through which to assess the potential of data for value creation and for identifying the key design areas in the context of IISs. Previously published work discussed certain activities and resources related to the use of data but did not provide an integrated view of those activities and resources. A comprehensive framework is required for the development and operation of IISs in this data-rich economy. The main contribution of this paper is the development of such a framework for understanding and managing the full spectrum from data to value in IISs. In addition, our work is significant in that it provides action research consisting of multiple projects and combines the analysis of multiple cases with action research to maximize the generality of the findings.

This study has a number of limitations that can be addressed by future studies. First, given that our work was a qualitative study (although several projects involve data analytics and are quantitative in nature), we cannot guarantee that our nine factors are exhaustive. This is why we analyzed 149 service cases in addition to the six action research projects to meet the generality criterion. Moreover, we do not consider the set of nine factors to be the sole answer. Different researchers may identify different factors based on different projects (e.g., some researchers may split the fourth factor (data analysis) into two factors (e.g., data management and analysis) as we did early in the research process. Some (e.g., 30%) of the fundamental aspects of data-based value creation may be disregarded in our findings. By contrast, we consider our contribution to be the identification of some of the remaining (e.g., 70%) fundamental aspects through our original empirical action research. Thus, we believe that our findings should be used, criticized, and complemented by future research.

Second, this study did not investigate the extent to which each factor affects the value creation in IISs. Additional empirical studies on the nine factors are required to determine the relative impacts of the factors in different contexts. For example, customer perception of the nine factors may differ between the context of heartbeat monitoring services (a B2C service for humans) and that of PHM services (a B2B service for engineering systems). Third, this study suggests a design approach to IISs based on the proposed nine factors. The main scope of this study was the set of the nine factors itself; the design approach is outside this scope. Thus, our discussion does not directly address the design approach itself. Nonetheless, the nine factors could be used and tested further in additional IIS or information system design studies in the future to ensure the development of a solid design method for IISs.

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