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Chiehyeon Lim
*School of Management Engineering, Ulsan National Institute of Science and Technology, Ulsan, Republic of Korea and School of Business Administration, Ulsan National Institute of Science and Technology, Ulsan, Republic of Korea*
Min-Jun Kim
*UX Team, Samsung Electronics R&D Center, Seoul, Republic of Korea*
Ki-Hun Kim and Kwang-Jae Kim
*Department of Industrial and Management Engineering, Pohang University of Science and Technology, Pohang, Republic of Korea, and*
Paul P. Maglio
*School of Engineering, University of California, Merced, California, USA*

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## Abstract

**Purpose** – The proliferation of (big) data provides numerous opportunities for service advances in practice, yet research on using data to advance service is at a nascent stage in the literature. Many studies have discussed phenomenological benefits of data to service. However, limited research describes managerial issues behind such benefits, although a holistic understanding of the issues is essential in using data to advance service in practice and provides a basis for future research. The purpose of this paper is to address this research gap.
**Design/methodology/approach** – "Using data to advance service" is about change in organizations. Thus, this study uses action research methods of creating real change in organizations together with practitioners, thereby adding to scientific knowledge about practice. The authors participated in five service design projects with industry and government that used different data sets to design new services.
**Findings** – Drawing on lessons learned from the five projects, this study empirically identifies 11 managerial issues that should be considered in data-use for advancing service. In addition, by integrating the issues and relevant literature, this study offers theoretical implications for future research.
**Originality/value** – "Using data to advance service" is a research topic that emerged originally from practice. Action research or case studies on this topic are valuable in understanding practice and in identifying research priorities by discovering the gap between theory and practice. This study used action research over many years to observe real-world challenges and to make academic research relevant to the challenges. The authors believe that the empirical findings will help improve service practices of data-use and stimulate future research.

**Keywords** Big data, Action research, Data-use, Service advancement, Managerial issue, Theoretical implication
**Paper type** Research paper



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## 1. Introduction

With recent advances in data collection technologies, massive amounts and varied kinds of data are collected from individuals and firms in all industries (Atzori *et al.*, 2010). The proliferation of (big) data has brought about services in which data-use significantly contributes to value creation. Automobile manufacturers analyze vehicle condition and operations data collected from onboard devices via telematics, and they provide various types of useful information to assist drivers on fuel efficiency, safety, consumable, and navigation (Lim *et al.*, 2015). Insurance companies collect patient data and provide patients with healthcare-related information to improve healthcare safety, reduce cost, and develop sustainable relationships with them (OECD, 2013). Smart band-based fitness tracking services collect data from daily life, such as behavior, health, and food menu data, to help people achieve specific fitness-related goals, such as walking 10,000 steps a day (Takacs *et al.*, 2014). Screen golf training services rely on data of users' golf swings to train users in achieving better stances and swing angles (Jung *et al.*, 2010).

Yet despite such widespread application in practice, research on "using data to advance service" remains very limited in the literature (Ostrom *et al.*, 2015; Maglio and Lim, 2016). In particular, our literature review on this research priority revealed a surprising lack of empirical studies directed at exploring data-use for service advancement in practice, though such work is essential to make theories and methodologies relevant to practice. For example, while the utility and importance of data for advancing service have been highlighted in the recent literature (e.g. Saarijärvi *et al.*, 2014; Lim *et al.*, 2015; Ostrom *et al.*, 2015), actionable insights to better manage data-use in practice are lacking or not well-documented.

Our objective is to address this research gap. Here, we investigate data-use for service advancement through an action research approach that combines theory and practice in real projects with industry and government. "Using data to advance service" is fundamentally about change in organizations. Action research through intensive collaboration between researchers and practitioners is useful for identifying and understanding issues in such change and for making academic research relevant to practice (Avison *et al.*, 1999; Coughlan and Coghlan, 2002; Iversen *et al.*, 2004). We conducted five service design projects with industry and government that aimed to use specific (big) data to design services in automobile, transportation, healthcare, wellness, telecommunications, and information technology (IT) industries (see Section 3). The diversity of the five projects contributed to gaining multiple insights on data-use. Drawing on lessons learned from the projects, we empirically identify 11 managerial issues that should be considered in using data to advance service (see Section 4). This work has been done based on the relevant literature (see Section 2), and thereby we also derive theoretical implications by connecting practice and theory (see Section 5). In explaining each issue and implication, this paper provides real stories from the five projects.

Empirical understanding of practice is essential to develop a new theory or improve an existing theory (Ketokivi and Choi, 2014). In this context, our work may be useful to stimulate future research to support effective date-use for advancing service. Although service researchers have studied technology-mediated service (Schumann *et al.*, 2012), information-intensive service (Lim and Kim, 2014), and smart service concepts (Wünderlich *et al.*, 2015), the use of IT for service advancement is not well understood despite its significance in the service research field (Nambisan, 2013; Breidbach and Maglio, 2015). There are some related studies from other fields, such as data collection and analytics in engineering (e.g. Barnaghi *et al.*, 2013) and system design in information systems (e.g. Friedman *et al.*, 2013); however, their applicability may be limited because they do not focus on service contexts. Studies on new service development (NSD) may be used for advancing service with data (e.g. Goldstein *et al.*, 2002; Jin *et al.*, 2014); however, they do not

focus on the context in which data-use is key to value creation and do not consider newly emerging data, such as sensor data. As such, "using data to advance service" is a truly interdisciplinary research topic. One of the challenges in our action research projects was to integrate and customize existing knowledge of different experts for the context of data-use for service advancement. Thus, the findings of our work are grounded in and integrate existing work from both inside and outside the service literature.

## 2. Literature review

### *2.1 Using data to advance service*

Research on using data to advance service is highly relevant to existing technology-based service concepts in which "there is an interaction between customers and technology-embedded objects such as a computer, the internet, or a machine at the moment of truth" (Noh *et al.*, 2016), such as technology-mediated service (Schumann *et al.*, 2012), mobile service (Niemelä, 2006), and smart service (Maglio and Lim, 2016) concepts. Whereas the technology-mediated service and mobile service concepts emphasize efficient delivery of information to customers, data-use for service should also consider creating information that helps people achieve their goals and on collecting the data to create useful information (Lim and Kim, 2015). From this perspective, data-use for service concerns the whole spectrum of information-intensive service value creation (Karmarkar and Apte, 2007). Though an essential aspect of smart services (Medina-Borja, 2015) is the intensive use of data (Maglio and Lim, 2016), smart services generally require an intelligent object (Wünderlich *et al.*, 2015) and some cases of data-use for service do not (e.g. use of medical insurance data).

Data-use matters in service research and practice as a way to create customer value and advance service (Ostrom *et al.*, 2015). Data generated by customers, also referred to as customer data, are useful to understand patterns of customer behavior, and are therefore useful in obtaining improved readings of market sentiment (Boyd and Crawford, 2011). Customer data analysis can determine why customers make certain decisions and behave in a certain way (Huang and Rust, 2013). In short, customer data are the resources that can help organizations understand their customers. Based on an improved understanding of customers, the use of customer data further contributes to advancing service: customer data can bring multiple opportunities to firms, such as value diversification, new revenue generation, customer loyalty increase, new market identification (Saarijärvi *et al.*, 2014), information content production, service concept design (Lim *et al.*, 2015), and servitization for manufacturers (Opresnik and Taisch, 2015). Furthermore, the use of customer data can foster a mutually beneficial relationship between a firm and its customers (Payne and Frow, 2005), and possibly between the firm and society (Kumar *et al.*, 2013).

Apart from data generated by customers, data generated by service providers or partner organizations are also useful in advancing service. Hospitals analyze their operational data to measure the quality of healthcare service and to derive useful information for doctors and hospital administrators to improve service quality (Yoo *et al.*, 2014). Air pollution monitoring services analyze data from pollution sources across a city to disseminate pollution-related information to the public (Kwon *et al.*, 2007). Smart cities collect data from cameras and sensors in the city to address the weather, energy, safety, and other concerns of citizens; for example, the Rio de Janeiro Government developed a flood prediction model based on land survey data, precipitation statistics, and radar data (Kitchin, 2014).

The use of data for service development and operations involve several activities (e.g. data collection) and resources (e.g. data analysis system), and these factors determine the data-based value creation mechanisms in services. Opresnik and Taisch (2015) discuss how the collection and storage of data from customers, analysis of data about customer

behaviors, and new information production for customers enable services in manufacturing industries. Raghupathi and Raghupathi (2014) outline an architectural framework for big data analytics in healthcare, which includes data sources, data transformation, and data analytics applications. Atzori *et al.* (2010) define the key resources needed to create the Internet of Things, such as sensing and communication technologies, and a software layer or a set of sub-layers interposed between the technologies and the application. Information use in services involves information production from data and information delivery to customers (Lim and Kim, 2014). A smart, connected product is one in which physical, smart, and connectivity resources are integrated to provide novel functions (Porter and Heppelmann, 2014).

Some of these studies demonstrate that using data is a key to understanding and attracting customers, as well as improving activities of service providers. However, these studies mainly discuss the phenomenological benefits of data to service. Limited research describes managerial issues behind such benefits, although an articulation of the issues is essential in using data to advance service. Although some of these studies discuss activities and resources involved in data-use for service, no existing work provides a comprehensive framework that shows how different managerial issues should be considered together in performing the activities and using the resources. Our objective is to address this research gap to improve the data-use in service contexts. We believe action research that combines theory and practice in real business environments is useful to achieve this objective because action researchers (i.e. the authors) do not merely observe but actively work to accomplish organizational goals (Gummesson, 2000). This way, action researchers experience the complete spectrum of the practice in question, thereby gathering rich data and developing holistic understanding (Coughlan and Coghlan, 2002). Section 3 explains our research method and five service design projects with industry and government in detail.

### *2.2 Service design to advance service*

As described, a number of studies have investigated data-use for service, such as data-use for service value diversification (Saarijärvi *et al.*, 2014), service opportunity identification (Lim *et al.*, 2015), customer relationship management (Payne and Frow, 2005), service quality improvement (Yoo *et al.*, 2014), and servitization in manufacturing (Opresnik and Taisch, 2015). Service design, a multidisciplinary area that helps innovate services by bringing new ideas to customers (Ostrom *et al.*, 2010), is highly related with all these objectives and thus could serve as a core approach to stimulate using data to advance service.

The scope of service design in this paper corresponds to concept or process design in the NSD process. Researchers have developed NSD process models that define key activities required for developing services (e.g. Edvardsson *et al.*, 2000; Johnson *et al.*, 2000). A generic NSD process consists of five steps: opportunity identification, customer understanding, concept development, process design, and refinement and implementation (Kim and Meiren, 2010). A service concept includes the specific features of the service, indicating what to offer to customers and how to offer it (Edvardsson and Olsson, 1996), and mediates between the customer needs and strategic intent of the company (Goldstein *et al.*, 2002). A service process describes the process through which the service is produced (Fließ and Kleinaltenkamp, 2004) and delivered to a target customer (Bitner *et al.*, 2008). In service process design, the details associated with the service process are determined, such as the interactions between customers and employees, sequence of operational tasks and their interactions, the input and output of each task, and the responsibility of service personnel and technologies (Kim and Meiren, 2010). In refinement and implementation, service prototyping and testing are performed for proper service launch (Bae and Leem, 2014).

Developing knowledge for service design is a research area aimed at improving service value creation. Researchers have investigated the unique nature of service design in specific service contexts, such as information-intensive services (Lim and Kim, 2014), IT-enabled services (Yang and Hsiao, 2009), experience-centric services (Zomerdijk and Voss, 2010), prevention services (Sandler *et al.*, 2005), and product-service systems (van Halen *et al.*, 2005). There are various service design methods or tools, such as the multi-level service design method (Patrício *et al.*, 2011), the method based on the theory of inventive problem solving (Russian acronym: TRIZ) (Chai *et al.*, 2005), Information Service Blueprint (Lim and Kim, 2014). In using these methods or tools for service design, the design process should be iterative through evaluation of the design outcome and redesign (Johnson *et al.*, 2000; Goldstein *et al.*, 2002). The integration the maturity model and the NSD process models helps analyze and improve the completeness of NSD processes (Jin *et al.*, 2014). Customer involvement in the process is a strategy to improve the process (Lundkvist and Yakhlef, 2004). Appropriate arrangement of the actors in the process is crucial to the success of NSD (Gottfridsson, 2012). Management of creativity capabilities is another success factor of NSD (Giannopoulou *et al.*, 2014).

All these studies can be used as a basis for designing services with data since they provide generic knowledge. However, their applicability may be limited because they do not focus on the context in which data-use is the key to value creation. In addition, existing service design studies in the literature mostly rely on survey or observation-type data, which are essentially "research data" that involve a hypothesis before data collection, and do not cover the newly emerging types of data such as behavioral records collected from physical sensors of consumer electronics, which are "natural data" that were collected and archived independent to a specific research project. Extension of existing service design studies is necessary to correspond to the expansion of data and to enable effective service advancement in this data-rich economy. Our objective is to address this research gap. Section 3 introduces how our five projects used or considered newly available data for service advancement.

## 3. Action research through five service design projects

### *3.1 Research method selection*

This study aims to develop a holistic understanding of managerial issues in using data to advance service through action research with five service design projects. 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 particular 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). Action research is appropriate to achieve our objective because action research is concerned with bringing about change in organizations (Shani and Pasmore, 1985) and our study is concerned with change (i.e. service advancement) through use of data; action research aims at developing holistic understanding (Coughlan and Coghlan, 2002) and our study explores a complete spectrum of data-use for service advancement; and foremost, the research topic of using data to advance service emerged from rapidly evolving practice and our study aims to investigate and help improve practice by offering specific actionable knowledge to practitioners.

Active participation of researchers in practice is critical to achieving such research objectives, and we concur with Huang (2010) that close observation is possible only through action and therefore legitimate understanding can be developed only through action. For example, we believe understanding of data-use for service advancement requires real experience on the use of real (big) data in specific projects. Action research always involves two goals: to solve a problem or exploit an opportunity and to contribute to science

(Coughlan and Coghlan, 2002). We have conducted multiple service design projects with industry and government to use (big) data in advancing real service systems (i.e. the first goal of action research) and to identify practical and theoretical issues in the data-use through learning during and retrospect after the projects (i.e. the second goal).

### *3.2 Researcher-client agreement*

Action research studies are embedded in specific contexts in practice. Thus, the clear specification of problem setting is a key element of action research to present the contextual aspects of a study and to discuss the transferability of findings about the research question (Mathiassen *et al.*, 2012). Moreover, in action research, researchers should be immersed in the practical problems of clients that should be addressed by the research. Academics cannot simply select action research projects, as they do for case studies; these projects should emerge naturally based on a researcher-client agreement for problem solving, which also reflects industry demand (Lüftenegger *et al.*, 2017). Thus, we clarify the organizational context for collaboration in this section to show relevance of such naturally emerging projects to the original research question.

The authors of this paper are affiliated with engineering schools in different universities and have collaborated with industry and government on various projects for the analytics of their data and improvement of their data-use (e.g. Lim *et al.*, 2015; Kim *et al.*, 2017). The findings of this paper are mainly based on the five projects presented in Table I. In Project 1, we designed services for the automobile industry; in Project 2, we designed a service for the transportation industry; and in Projects 3, 4, and 5, we designed services for the health industry. All projects are highly relevant to the IT industry.

The original research question of this paper on "using data to advance service" was initiated after a project on the quantitative evaluation of the impact of customer loyalty management services conducted in 2010 with a major automobile manufacturer. With the project's success, the automobile manufacturer contacted us in September 2011 and requested a research team to use a large database to advance their services. We were greatly interested in investigating the mechanisms and issues of using data to advance service as attention to "big data" and "service science" were increasing rapidly in both industry and literature. Accordingly, Project 1 was initiated on October 2011 with both practical and academic motivation; the automobile manufacturer of Project 1 had collected vehicle operations and condition data and was interested in developing services for customers using the data.

As for Projects 2-5, clients (i.e. industry and government organizations) aimed to use specific data sets for service advancement, and the researcher-client agreements were developed in similar contexts: The transportation division of government of Project 2 was concerned with driving safety of commercial vehicle drivers (i.e. bus, taxi, and truck drivers) and had collected operations data from vehicles through the use of digital tachograph (DTG) devices; and the institute wanted to develop services with the DTG data to manage the drivers. The healthcare division of government of Project 3 had collected various types of data, including insurance, diagnosis, treatment, and medical examination data; and the healthcare division was alarmed about the cost of treating hypertension and wanted to provide data-based hypertension management services to using data from the national health insurance database. Furthermore, through Project 4 the healthcare division aimed to design service concepts that would serve as bases for the health service innovation with the national health insurance database. The IT company of Project 5 had developed a platform to manage and analyze (big) data and aimed to design services operating on the platform. All clients showed interest in the use of data to improve existing services or to design new services. We were interested in understanding and improving the "service-oriented" data-use process and wanted to increase the diversity and number of cases to achieve a generally comprehensive understanding of the research question, these projects fit our purposes well.

| Subject | Project date | Client (informant) | Analyzed or considered data for service design | Summary of analysis and outcome |
|---|---|---|---|---|
| Project 1: Car infotainment service design | October 2011-June 2012 | Automobile manufacturer | Passenger vehicle operations and condition data | Designing car infotainment services for individual drivers that use vehicle operations and condition data, based on analyses of 7.6 million trip data of 18,943 vehicles (vehicle operations data) and 3,662 cases of warning code occurrences (vehicle condition data) |
| Project 2: Driving safety enhancement service design | April 2013-May 2014 | Transportation division of government | Vehicle operations and accident data of commercial vehicle drivers | Designing driving safety enhancement services for commercial drivers that use vehicle operations data, based on analyses of operations data of commercial vehicles (278 buses, 46 taxis, and 931 trucks) and accident data of commercial vehicle drivers (4,289 bus, 1,550 taxi, and 490 truck drivers) |
| Project 3: Hypertension patient management service design | June 2013-May 2015 | Healthcare division of government | National health insurance data | Designing hypertension patient management services that use national health insurance data, based on analyses of a sample data set from the database for 1 million people for 9 years (2002-2010) |
| Project 4: Health care and insurance service design | April 2014-October 2014 | Healthcare division of government | National health insurance data | Designing health care and insurance services for health-related stakeholders with a government organization, based on interviews about the use of national health insurance data with 34 experts such as doctors, public health scientists, managers and executives in the industry, and government employees |
| Project 5: Smart wellness service design | January 2015-Decemeber 2015 | IT company | Daily behavior data | Designing a smart wellness service for college students that use daily behavior data of students, with an IT company and a student counseling center at a university based on data from 47 students, as well as based on investigation of wellness hindrance factors, available records, and indices |

**Table I.**
Five service design projects conducted to investigate the nature of using data to advance service

### *3.3 Research framework*

This section details our action research framework; Table II summarizes the elements of our action research practice (following Mathiassen *et al.*, 2012). Our area of concern and the problem setting were described previously in Sections 2.1 and 3.2, respectively. Action research can serve as a platform on which additional research methods can be adopted (Germonprez and Mathiassen, 2004). In our case, we used the literature on service design and NSD introduced in Section 2.2 (e.g. Johnson *et al.*, 2000; Goldstein *et al.*, 2002; Patrício *et al.*, 2011) as a basis for the problem-solving cycle across all our projects to systemize the process of using data to advance service. Researchers rely on a variety of action research forms and processes (Mathiassen *et al.*, 2012). We also used several different research processes across projects, customized to the unique problem setting and project environment.

| Action research element | Current work |
|---|---|
| Area of concern | The use of data to advance service is the area of concern. Section 2.1 describes some bodies of knowledge within the literature |
| Problem setting | Problem setting in action research represents people's concerns in a problem situation. See Section 3.2 for the problem setting in the five projects |
| Conceptual framing | Considering that the research on data-use to advance service is at a nascent stage and is a truly interdisciplinary research topic, no single concept in the literature can sufficiently cover the full area of concern. The current work reviews and uses a wide range of studies through the five projects. See Sections 2.2 and 5 for reference |
| Method guiding the problem-solving cycle | The problem-solving cycle in action research focuses on producing practical outcomes. The literature on service design and NSD in Section 2.2 served as a basis to guide problem solving for project clients. See Figure 2 and Section 3.4 for the detailed service design processes |
| Method guiding the research cycle | The research cycle in action research focuses on producing research outcomes. See Figure 1 for our research cycle over five years. Our unique approach is to combine multiple projects of action research to generalize the findings |
| Contributions | Sections 4 and 5 present the practical and theoretical contributions of the current work. The contributions include understanding the area of concern, developing a basis for the conceptual framing for future research on using data to advance service (i.e. contribution to the literature in Section 2.1), and improving the method guiding the problem-solving cycle on using data to advance service (i.e. contribution to the literature in Section 2.2). In addition, the current work is significant in that it provides an action research case consisting of multiple projects and combines the service design and NSD literature with the action research literature |

**Table II.**
Elements of the current work as action research

In what follows, we present our research framework in detail based on some key action research references (e.g. Avison *et al.*, 1999; Iversen *et al.*, 2004; Mathiassen *et al.*, 2012).

Figure 1 depicts our action research framework, including the problem-solving cycle in each project and the research cycle across the five projects. For the research cycle in Figure 1, the main reason for combining the five projects was to accumulate the lessons from different projects to develop our findings in a step-by-step manner and to enhance the generality of our

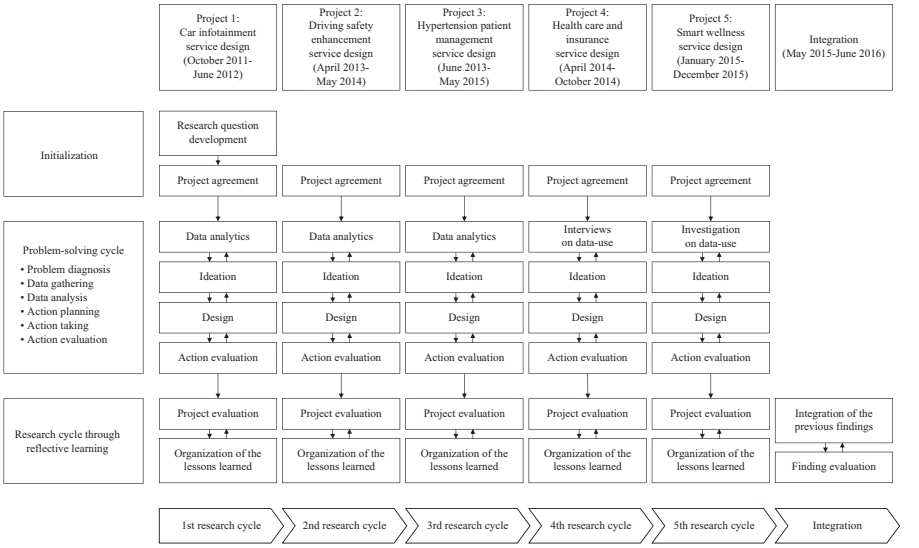


**Figure 1.**
Research framework

final results. For the problem-solving cycle in Figure 1, an action research project solves problems through problem diagnosis, data gathering, data analysis, action planning, action taking, action evaluation, and reflective learning (Avison *et al.*, 1999; Coughlan and Coghlan, 2002; Iversen *et al.*, 2004). In the current work, "action" refers to the actions involved in the data-use process for service advancement; these actions include data collection, data analytics, information creation, and information delivery design (see the first paragraph of Section 2.1). Therefore, we planned, took, and evaluated these actions following the method guiding the problem-solving cycle. Note that "data" in the problem-solving cycle and "data" in the project processes are different. The former refers to data for action planning in the project, whereas the latter refers to data for service advancement of the client. Projects 1, 2, and 3 involved analytics of real (big) data before ideation, whereas ideation in Projects 4 and 5 were mainly based on expert interviews and literature investigation on the interested data types; in Project 4, we analyzed real wellness data collected through smart bracelets in the pilot run (action evaluation) step.

Figure 2 shows the detailed service design processes used in the five projects. The general process can be categorized into four steps: preliminary investigation and opportunity identification, which include problem diagnosis, market investigation, and analysis of data from customers and experts; service idea generation and refinement, which include the derivation of ideas from data analysis or expert interviews and the design of information contents for customers; service concept and delivery process design, which incorporate the design of service concepts and their delivery processes; and validation and implementation issue identification, which contain the evaluation of designed services with experts and customers and the identification of service improvement and implementation issues.

The service design process in each project corresponds to the steps of action research: that is, preliminary investigation as the problem diagnosis, data gathering, data analysis, and action planning; opportunity identification, service ideation, and service design as the action taking; validation and implementation issue identification as the action evaluation; and our interpretation during and after the projects correspond to the reflective learning. All projects involved monitoring, evaluation (by both researchers and practitioners),

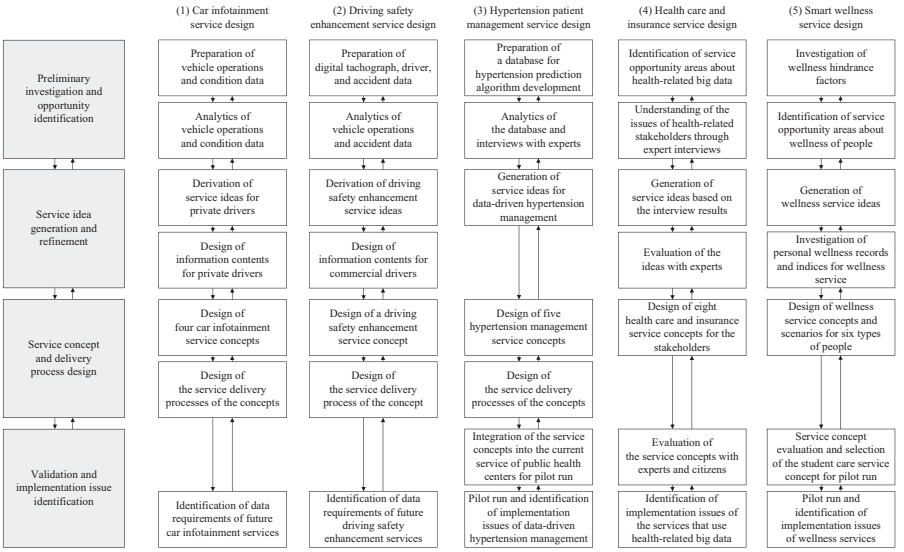


**Figure 2.**
Service design processes used in the five projects

and redo in performing these steps to maintain validity of action research (Coughlan and Coghlan, 2002); for example, Step 1 in Project 2 involved analysis of sample data, identification of data quality issues, request of data to the client after specifying the data requirements, and analysis of quality data. This way, we could learn about both practical and theoretical issues in using data to advance service. Section 3.4 introduces each of the five projects in turn.

Our research complied with the criteria and principles of action research in the literature. Table III describes our work according to the six criteria of action research (Iversen *et al.*, 2004). Principles of action research (Davison *et al.*, 2004) were maintained as follows. For the principle of researcher-client agreement, the focus of the research project was specified clearly and explicitly in the contract phase of any project. For the principle of cyclical problem-solving process, the planned actions were based explicitly on results of the diagnosis in the investigation phase of any project. For the principle of theory, the domain of investigation and the specific problem setting were relevant and significant to the interests of the researchers' community of peers and the client before the start of any project. For the principle of change through action, both researcher and client were motivated to improve the situation throughout any project. For the principle of learning through reflection, research activities and outcomes were reported clearly and completely at the end of each project for reflection.

After Project 1, we organized lessons learned, and then following Projects 2-5, we documented and accumulated the lessons to develop a comprehensive framework for advancing service with data. During Project 5, we discovered only marginally new lessons for using data to advance service. After seeing the call for research on using big data to

| Action research criteria | Current work |
|---|---|
| Roles | The roles of researchers and practitioners were clarified in the contract phase of any project. Researchers generally performed all problem diagnosis, data gathering, data analysis, action planning, action taking, and action evaluation, whereas practitioners support these steps and evaluated the outcomes |
| Documentation | The quality of data used in the project was ensured through the presentation of the data collector and evaluation of the other party. For example, the researchers evaluated the quality of vehicle operations and accident data collected by the practitioners in Project 2. On the contrary, the researchers interviewed experts for data collection, and the practitioners evaluated the results in Project 4. Consequently, poor data were excluded after the evaluation in any project |
| Control | The contract between the research team and client organization established the researcher-client relationship. The organization funded the research. Thus, the organization executive and principle investigator exercised authority over the project process. Practitioners controlled the problem-solving cycle through regular meetings for evaluation |
| Usefulness | The practitioners and researchers evaluated usefulness of the planned actions. Practitioners mainly measured short-term usefulness for their own problems (i.e. specificity), whereas the researchers were concerned about long-term usefulness for academic findings (i.e. generality) |
| Theory | Phenomenological studies on using data to advance service (e.g. studies in Section 2.1) provided a theoretical basis to the current work. The literature on service design and NSD (e.g. studies in Section 2.2) provided a methodological basis. The integrated findings in Sections 4 and 5 contribute theoretically to understanding of data-use for service advancement and to facilitating the service design and development with (big) data |
| Transfer | These findings can be transferred or adapted in many other contexts. The five projects were combined mainly to achieve generality of findings. In addition, we applied these findings to other projects to test transferability; see the last paragraph of Section 3.3 |

**Table III.**
Action research criteria met in the current work

advance service (Ostrom *et al.*, 2015), we concluded that the timing is right to integrate findings from Projects 1 to 5. Thus, from May 2015 to June 2016, we reviewed, integrated, and analyzed findings from all five projects through multiple discussions among the authors. Findings included the characteristics of the (big) data analyzed for service design, methods for data collection, processes of the performed data analytics and service design, insights from experts (e.g. interviewed researchers and practitioners in the client organizations) on data-use for service, related business cases benchmarked for service design, and architecture of designed services.

Specifically, we analyzed and categorized the integrated results, guided by the following research question: "What are the managerial issues in the use of (big) data to advance service"? For example, from Project 2, we identified the issue of managing data quality for service, as we received poor quality data at the beginning of the project and requested the client improve quality; and from Project 4, we identified issues on customer privacy protection in using data from the expert interviews. We looked for both similarities and differences across the five projects for generalization, initially identifying 22 managerial issues. We then checked whether these issues covered all the cases, and vice versa, and modified (e.g. combined, divided, or renamed) the issues when appropriate. To prevent bias, three authors evaluated the applicability of the issues to the projects in which they did not participate and shared their evaluation results. We repeated this refinement process several times and finally arrived at a set of the 11 managerial issues described in Section 4. Our primary concern in this process was to identify issues that would best represent the knowledge we gained through the action research projects with practitioners and the insights we gathered from our interviewed experts. Finally, we reviewed the information obtained from Projects 1 to 5 by mapping them onto the set of 11 issues to systematically organize our findings.

Furthermore, we applied the issue set (the framework in Figure 3) in improving other service design projects in the context of data-use and then confirmed its utility. For example, a new project designed an eco-driving support service for bus drivers that use vehicle operations data, based on analyses of bus operations and fuel consumption data of 33 bus drivers. In this project, we requested to the client (a transportation division of government) in advance to manage the quality of data for service (related to Issue 3; see Section 4 for detail on this issue) and could improve the performance and validity of the fuel efficiency prediction model for eco-driving support service.

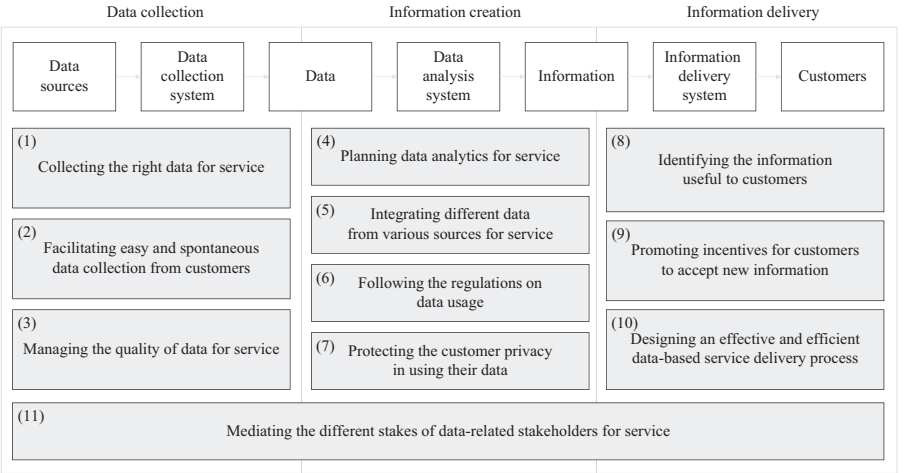


**Figure 3.**
Managerial issues that should be considered in using data to advance service

*3.4 Detailed processes of the five service design projects*

This section introduces the five projects in which we studied the use of data to advance service, as guided by the literature on service design and NSD. We believe the approaches and outcomes of each project can be used as references to develop similar initiatives for future projects.

In Project 1, we designed four car infotainment services with a major automobile manufacturer. The service design process followed the seven steps in Figure 2. First, data from a total of 7.6 million trips were prepared regarding the driving of 18,943 vehicles (19,063 customers) in 2011 (vehicle operations data). In addition, 3,662 cases of warning code occurrences from 2009 to 2012 (vehicle condition data) were prepared. Second, the data analysis results included descriptive statistics of the driving patterns of customers, key variables that determine driving characteristics, as well as the relationships among warning codes. Third, the data analysis provided cues for deriving 26 service ideas, which were categorized into four groups: driving capability enhancement, context-aware driving support, customer relationship management, and car and life. Fourth, the information contents for customers were designed, including daily and monthly vehicle operation review, diagram of a customer's safe driving ability, and remaining lifetime of consumables. Fifth, four service concepts were designed, namely, services for fuel efficiency improvement, driving safety enhancement, consumable replacement support, and prognostic maintenance support. Sixth, the service delivery processes were blueprinted. Finally, a set of data requirements for future car infotainment services was identified as a strategy for the company to develop its service capability with data.

In Project 2, we designed a driving safety enhancement service with a government transportation safety institute. The service design process was similar to that in Project 1. The types of data prepared in the first step included DTG (e.g. driving time, velocity, GPS, brake on/off, and RPM), driver (e.g. driver name, driving time, and car plate number), and accident data (e.g. driver name, accident type, time, and place). The three types of data were integrated to analyze the driving behaviors of a particular driver. The data analysis results in the second step included the correlations among risky driving behaviors, the risky driving behavior frequency in specific routes, and the comparison of different driver groups according to their risky driving behaviors. The data analysis provided cues for deriving service ideas in the third step. The information contents designed in the fourth step included distribution of the risky driving behaviors of an individual and comparison with other drivers in terms of the frequency of risky driving behaviors. The concept and delivery process of a driving safety enhancement service that delivers such information to drivers with accident records were designed in the fifth and sixth steps. Finally, a set of data requirements for future driving safety enhancement services was identified as a strategy for the institute to develop its service capability with data.

In Project 3, we designed a hypertension patient management service with a government organization. The service design process followed the seven steps in Figure 2. First, a database for hypertension prediction model development was created based on the cohort database of national health insurance system. The database contained insurance data, diagnosis history data, treatment history data, medical examination data, and hypertension onset data from 2008 to 2010 of citizens who did not have hypertension before 2008. Second, the database was analyzed to develop a hypertension prediction model. Focus group interviews were conducted with 17 experts to identify key issues of data-based hypertension management. Third, 48 service ideas for data-based hypertension management were generated, including e-health education service for self-hypertension management and messaging service for high-risk hypertension patients. Five service concepts and their delivery processes were developed in the fourth and fifth steps, namely, self-blood-pressure-control service, hypertension counseling support service, personalized hypertension education service,

hypertension medication support service, and information portal service for hypertension patients. Sixth, the service concepts were integrated into the current service of public health centers for pilot run. The finally designed service (i.e. integrated service) identified high-risk hypertension patients based on the hypertension prediction model, and provided a warning and a guide for people to visit public health centers and get a checkup. Seventh, a pilot test was run at a public health center and implementation issues of data-based hypertension management were identified, such as the use of more data collection methods (e.g. wearable devices) and the public relations of government-driven personalized healthcare services.

In Project 4, we designed eight services for health-related stakeholders with a government organization that operates the national health insurance system. The service design process followed the seven steps in Figure 2. First, through a series of brainstorming sessions based on related studies, major service opportunity areas that could be enabled based on health-related data were identified, including public health service innovation, private service innovation, and national insurance service innovation. Second, focus group interviews were conducted with 14 experts, such as doctors, public health scientists, managers, and executives in the industry, and government employees, to understand the issues of the stakeholders such as citizens, hospitals, and government organizations. Third, 138 service ideas were generated based on findings from the previous steps, including personal health scoring, hospital search, medical equipment sharing, and regional health statistics services. Fourth, new focus group interviews with 20 experts were done to evaluate these ideas. Fifth, brainstorming sessions were held to transform the information, knowledge, and insights gained from the previous steps into several service concepts. As a result, eight new service concepts were developed for the stakeholders, such as the "cloud family doctor" service for citizens, which provides information on healthcare derived from the data of a citizen, who could access the service via smartphones and websites. The service also aimed to support doctors in efficiently accessing and using patient data. Sixth, 19 experts and 612 citizens were surveyed to evaluate the eight service concepts qualitatively and quantitatively. Finally, implementation issues of each service were identified, such as the key value that should be created for the target customers, requirements of the data for service, key partnership for service, challenges of the service, and ideas to address challenges.

In Project 5, we designed a smart wellness service for college students with an IT company and a student counseling center at a university. The service design process followed the seven steps in Figure 2. First, factors in daily life that hinder wellness of specific types of people were investigated, such as workers, children, and students. The factors included poor quality of sleep, lack of exercise, irregular eating habits, and subjective stress. Second, wellness service opportunity areas were identified, such as stress management, body condition monitoring, and sleep regulation. Third, service ideas about the opportunity areas were generated. Fourth, the literature on existing personal wellness records were investigated, along with indices that may be required to operate the wellness services to be designed. Fifth, wellness service concepts and scenarios for six types of people were designed, including college students, production workers in the steel industry, soldiers, babies, truck drivers, and fitness center customers. Sixth, the six service concepts were evaluated based on marketability, differentiation, and feasibility. Then, the service concept for college students was selected for further development and pilot run, which measured a daily wellness index of a college student with the student's daily behavior data, such as daily sleep time, daily diet records, and walking steps collected through smartphones and activity trackers. Finally, a four-week pilot run was conducted to test the developed service for college students. During the pilot run, health-related behavioral records were collected from 47 students who participated to the pilot run. The data were analyzed to refine the designed service. Implementation issues of wellness services were also identified based on the insights from the pilot run, such as the wear-ability of smart devices, the annoyingness of manual data input, and the connection with professional wellness knowledge providers.

## 4. Managerial issues in the use of data for service advancement

As with any large-scale initiative for change, the move to effective data-use for service was not easy. Our action research into this change through the five projects involved the analysis of real (big) data to understand customers, design of information content for customers, analysis of existing service cases in multiple industries that involved intensive data-use, interviews with experts and practitioners who had extensive experience related to data-use and service management, design and evaluation of new service concepts, and so on. All these activities were organized based on the literature including the studies reviewed in Section 2, performed through intensive collaboration with practitioners, and analyzed coherently to understand effective ways to use data for attractive and workable services. As a result, 11 managerial issues of data-use for service advancement were identified (see Figure 3). Studies reviewed in Section 2.1 indicate that services in which the use of data has a highly significant effect on value creation involve data collection, information creation, and information delivery activities (e.g. see the first paragraph of Section 2.1). As shown in Figure 3, each issue is classified based on its relevance to each activity, with the last issue being highly relevant to all three activities.

### *4.1 Issues related to data collection*

Issue (1) pertains to the collection of the right data for service. The database analyzed in Project 1 was developed by the engineering department of the automobile manufacturer, which gave little consideration to the use of data in services for customers. The database was useful in diagnosing and maintaining vehicles for engineers, but provided limited understanding on the driving patterns of customers. Thus, the database was limited in terms of service development and operations for customers. For example, GPS data were not collected, and vehicle operations data were recorded in the form of aggregated data in each trip (e.g. average speed and number of rapid accelerations in a trip). Therefore, information on where and how customers drive was limited. This limitation hindered the deeper understanding of a customer's driving patterns. In contrast, the DTG data used in Project 2 were tallied every second and had GPS information. Moreover, Project 2 additionally collected driver data from transportation companies and accident data from the national police agency to understand driving patterns in terms of safety, as well as to design effective driving safety enhancement services. We found that "identifying and preparing the right data for service is crucial in data-use for service advancement because the data determine the scope and potential of service."

Issue (2) pertains to the facilitation of easy and spontaneous data collection from customers. Data collection can be an annoying and sometimes time-consuming task for individuals, often involving deliberate interaction with technology. For example, an expert interviewed in Project 4 mentioned that self-testing of blood sugar is an annoying task for diabetic patients and many patients do not want to show the testing process and needle marks to others, hindering continuous collection of blood sugar data for quality service. In contrast, another expert said that doctors spend a lot of time creating electronic medical records, which causes them to seek new wearable devices to enhance the efficiency of data recording and loading. This issue is also important in the automobile industry. Data collection by the automobile manufacturer in Project 1 was fully automated, whereas data collection in Project 2 required drivers and company managers to manually transmit the DTG data to the government institute. In Project 2, a manager of the government institute had to remind drivers and managers to provide the data. In the pilot run of the designed service in Project 5, we also collected manual data from students aside from the automatic data collection through the wearable device; to minimize the burden for the

students, we only asked them to check if they ate breakfast, lunch, dinner, and drank alcohol and to record the quality of meal. We found that "identifying user-friendly methods or incentives for data collection is crucial in data-use for service advancement, because the data collection methods determine the experience of customers and efficiency of service."

Issue (3) pertains to managing the quality of data for service. A prerequisite for providing trustworthy and reliable services with data in any industry is to guarantee the quality of data used in the service. In Project 2, several vehicle operations data collection devices generated incorrect data, such as strange or missing values. Moreover, different vehicles used data collection devices from different manufacturers, which generated an unnecessarily large variance in the analyzed data. The data quality of driving schedule and accident history was also poor. In Project 2, the poor quality of data was attributed to the lack of a specific department that manages data. Conversely, the quality of the data used in Project 1 was relatively good. Only a few problems pertaining to data quality occurred because a specific department was involved in managing data. Credibility of service is particularly important in the health industry, given that these services concern human health. However, much of the data in the health industry is qualitative and inaccurate. Some of the data in Project 3 obtained from the national health insurance database were not fully standardized and were inaccurate. Thus, developing the high-performance model for hypertension prediction was challenging. In this respect, some of the interviewed experts in Project 4 mentioned that the poor quality of the data hindered its use in the health industry to develop new services. We found that "the quality of available data should be evaluated and ways to enhance quality should be identified when advancing services with data to come up with workable services."

### *4.2 Issues related to information creation*

Issue (4) pertains to planning data analytics for service. Ideal data analytics for service design is almost impossible because of the resource constraints and the availability of appropriate and quality data, as discussed with Issues (1) and (3). For example, in Projects 1 and 2, only a limited number of data analytics plans could be implemented. Thus, at the initial stage of each project, we first identified several data analytics plans that were expected to be useful to attract drivers (i.e. customers) and to help practitioners. However, this task was challenging because planning data analytics for service design requires various types of knowledge, including data mining, service design, and the domain problem. Likewise, Projects 3 and 5 required expertise on hypertension onset and stress management to develop data analytics plans, respectively. In particular, health-related services must be designed and operated based on solid evidence from quality data analytics because these services concern human health. Thus, some of the doctors interviewed in Project 4 expressed grave concerns about the accuracy of the data analytics result for health-related services that will be delivered to patients. We found that "identifying a list of possible data analytics scenarios and developing reliable plans for service should be conducted in using data for service advancement to understand customers and their concerns accurately and to provide reliable information to them."

Issue (5) pertains to the integration of different data from various sources for service. Our five projects show that various types of data come from different sources. The key point is connecting these data to deliver high-level information to customers, thus enhancing value. However, establishing the connection between data from different sources is not easy because different organizations use different data structures. Integrating the driver, driving, and accident data was a challenge in Project 2 because these data were separately archived in the databases of transportation companies, vehicles, and the government. Likewise, different data from different databases were integrated in Project 3 to prepare a specific database for developing a hypertension prediction model. This task was very

time-consuming and required expertise on both chronic disease diagnosis and data mining. Hence, many of the experts interviewed in Project 4 mentioned that data integration and standardization are the most urgent issues in the health industry that have hindered development of new and innovative services with data. An IT platform that connects, integrates, and manages different data from different sources would be useful to stakeholders who aim to create value with data. We found that "identifying a list of useful data for service and planning data integration should be conducted in advancing service with data to understand the possible design space and expand the space."

Issue (6) pertains to regulations on data-use. This issue is particularly important in the health industry because this industry is concerned with human health data. Industry operations should be controlled by firm regulations. However, the regulations are incomplete and sometimes must be altered when new technologies and paradigms emerge. For example, an expert interviewed in Project 4 mentioned that ownership of personal health records collected by an organization or a device is a controversial topic, and the scope of healthcare information that can be handled by non-doctors is also unclear. For example, a gene data analytics company in the USA had to narrow its business scope because of a sudden restriction by the Food and Drug Administration. In Project 4, a manager of an IT company complained that vague regulations on health-related data serve as a market entry barrier rather than a facilitator in the health industry. Efforts to service innovation should adhere to regulations to prevent unexpected problems, but the regulations should also be improved to facilitate spontaneous service innovations. We found that "investigating regulations related to the data and service in question is a prerequisite in using data for service advancement to create workable services and to identify implementation issues."

Issue (7) pertains to customer concerns for data privacy. Data from customers contain personally identifiable information. If data from an individual are leaked, the privacy of the individual may be seriously compromised. In Project 1, vehicle operations data were collected after the agreement of drivers. Likewise, the data used in Project 5 were collected based on the agreement of students before the pilot run of the designed service. The original data set provided by the government in Project 3 included a randomized personal ID, which was impossible to trace and excluded any data field containing personal information. In Project 4, we asked 612 individuals of their intention to use, their requirements on, and their priority for the designed services. Many respondents were concerned about their privacy regarding the designed services. They liked the value that the new services would likely create, but some explicitly stated that a prerequisite would be a guarantee of their privacy. This issue can be partially addressed by technology adoption and firm regulations. In this regard, Project 4 also involved designing an IT system and regulations to protect privacy in the use of health-related data. We found that "investigating the customer privacy issues and addressing these concerns are essential in data-use for service advancement to create valid and sustainable services."

### *4.3 Issues related to information delivery*

Issue (8) pertains to identifying information that is actually useful to customers. One of the main purposes of data-use in services is to understand the customers, create, and deliver useful information to them. Thus, identifying the right information in terms of content and form is a key factor to improve value creation. Projects 1 and 2 were initiated because previous services were not appealing to customers, and the service providers offered information to customers with little consideration of their needs. Some of the interviewed experts from the health industry in Project 4 mentioned that previous IT-based services in the industry were not appealing to customers for the same reason. Another expert mentioned that the use of data for service should be customer-driven rather than IT-driven, and a prerequisite is identification of the right information for customers.

However, identifying the right information from a large candidate space is a challenging task. Nonetheless, we have seen that analyzing data from customers can take the guesswork out of understanding customers and designing information content for them. We found that "determining useful information for customers is crucial in data-use for service advancement because what to deliver to customers with data is directly connected to the value and appeal of a service."

Issue (9) pertains to promoting incentives for customers to accept new information. Project 3 identified high-risk patients of hypertension based on a hypertension prediction model, and potential patients were warned and advised to visit public health centers. However, some people do not heed warnings. Thus, inducing them to accept the information was another challenge, and the project conducted an experiment to determine how to attract people. In the expert interviews in Project 4, an executive in charge of a wearable device-based fitness service pointed out that many of the patients do not accept health-related information because they do not know the reason for it. The health-related information sellers (i.e. service providers) should explain explicitly the reason customers should accept information (sometimes cordially and sometimes severely) and should devise ways to promote incentives. This job is challenging although service providers often have useful information to customers. Likewise, doctors are busy and do not have to or want to accept new information if the information seems to interrupt their existing activities. Thus, the wearable device-based student wellness service design in Project 5 involved a student counseling center to enhance the information acceptance of students by associating them to the care programs in the center through the service; most people listen to experts rather than to "Apps." Whereas Issue (8) concerns mainly the utilitarian aspect of services, this issue points out the arbitrariness of customers and the experiential aspect of services. Project 2 confirmed that although we know we must drive safely, some people do not. We found that "using data to advance service should involve an analysis of customer motives and the identification of incentives for customers to accept new or modified information."

Issue (10) pertains to designing an effective and efficient data-based service delivery process. As Figure 3 indicates, the delivery of a service to customers in the context of intensive data-use involves data collection from customers and information delivery to them. Even if Issues (8) and (9) are successfully addressed, designing the entire delivery process of a service involves decision points in determining when, where, by whom, how, and through which sequence should data be collected from customers and how information should be delivered to them. For example, some services monitor data from customers and aid them in real time, whereas some others archive the data for some time and provide information to customers periodically. This diversity in methods of service delivery makes it difficult to determine an optimal service delivery process. Beyond the customer-oriented perspective of Issues (8) and (9), this issue concerns additionally the operational aspects of service delivery from the provider-oriented perspective. In Projects 1-5, we observed that analyzing the contextual data (e.g. time and location of driving in Project 2) helps in designing the data-based service delivery process. Classifying the candidates for each decision point (e.g. potential information delivery channels and partners) is also helpful; for example, in Project 1, we classified the channel into e-mail, phone call, smartphone application, or onboard display. We also found that the process of data transformation into information for customers, as shown in Figure 3, is useful in designing a data-based service delivery process because each white diagram in the process indicates a building block of service delivery. We found that "designing an appropriate service delivery process is crucial in advancing service with data because this task integrates all the outcomes from the data analysis, customer understanding, service ideation, and information content design."

Issue (11) pertains to the different stakes of data-related stakeholders for service. This issue is highly relevant with all the three data collection, information creation, and

information delivery activities. Services involve various types of stakeholders. For example, services in the health industry involve patients, family of patients, healthy people, doctors, nurses, hospital administrative staff, and government employees. From Project 4, we understood that the conflict between stakeholders is one of the most critical factors that hinder data collection, information creation, and information delivery in the health industry. For example, an expert interviewed in the project mentioned that some doctors may not feel the need to collect additional data; medical treatment is an art to them, which should be their own area, rather than a technique that can be automated. Thus, we highlighted in the project that the designed services do not aim to replace the treatment but to complement it. Some of the individuals surveyed in the same project were worried that new services would increase medical insurance premiums. Similarly in Project 1, we found a gap between manufacturing-related (e.g. engineering and product design) and service-related (e.g. marketing and after-sales service) departments in the automobile manufacturer; the main objectives of data collection and information creation vary (e.g. improving the engineering systems vs improving customer experience), and the target customers were also different (e.g. internal engineers vs external customers). We found that "understanding and mediating the different stakes of data-related stakeholders is crucial in advancing service with data to enhance the potential and feasibility of service."

All these issues are related because data collection, information creation, and information delivery in a service are interdependent activities. For example, identifying the right information for customers (Issue 8) is a prerequisite for proper data analysis planning (Issue 4) and collection of the right data (Issue 1), and data analysis planning (Issue 4) is a prerequisite to planning about data integration (Issue 5).

## 5. Theoretical implications

Throughout our work on the five projects, we felt we could do a better job of problem solving if there were theories and methodologies for using new data to advance service. Given the 11 managerial issues, how can researchers help practitioners manage the use of data to advance service? Using data to advance service is a truly interdisciplinary research topic that requires combining different fields. We found multiple theoretical implications for using data to advance service through our action research in diverse projects, which were based on various studies in different fields, such as those introduced in Section 2.

More specifically, the following six items may be promising for future research in advancing service with data: use of natural records and combinatorial use of different types of data, use of customer process-related data collected through sensors, understanding of data-based value creation mechanisms, management of the customer experience about data and information, management of the synergy and conflict between data-related service stakeholders, and integration and customization of existing theories and methodologies into a single multidisciplinary framework for using data to advance service. We describe each of the six items and its relevance to the literature and 11 managerial issues in turn.

### *5.1 Use of natural records and combinatorial use of different types of data*

Studies on use of natural records and combinatorial use of different types of data are required to advance service with data effectively. Whereas existing studies on service design mostly used survey or observation-type data, which are essentially research data that involve a hypothesis before data collection, our action research demonstrates the utility of newly available natural records being collected and archived in advance, independent of a specific research project. Such data are digital traces of human activities or system operations and indicate states or characteristics of the data sources. For example, condition records, transaction queries, and bio-signals are collected from engineering systems,

business processes, and people, respectively. We found that such data are useful for services to the people or organizations (i.e. customers) that the data sources concern.

For example, from the perspective of Goldstein *et al.* (2002), we observed from Project 1 that the use of natural records on customer driving contributes greatly to service strategy formulation and service delivery method design for automobile manufacturers. At the beginning of the project, the manufacturer was not sure about its service strategy with the established database of vehicle operations and condition data. Thus, one of the project goals was to develop several service strategies for future business. As described in Section 3.4, our data analytics revealed that the database was useful for four strategical service areas: driving capability enhancement by measuring the driving performance; context-aware driving support by understanding the driving time, location, and environment; customer relationship management by understanding the driver's demographics and driving patterns; and car and life by sharing the data with other service organizations. In addition, we identified a set of data requirements for ideal car infotainment services as a future strategy for the company to improve its service capability with data. In this project, our analytics of natural records on customers was useful to develop an exact description of customers and thus helped practitioners understand which strategies are fully or potentially feasible at the moment. This project shows that the use of a large natural record database, often referred to "big data," contributes to exploring the unexplored space of service strategies and opportunities.

Through an evaluation session with practitioners, we agreed to focus on the driving capability enhancement area considering the quality of available data. As described in Section 3.4, we designed information contents for capability enhancement and services for fuel efficiency improvement, driving safety enhancement, consumable replacement support, and prognostic maintenance support. The information contents designed in this project included daily/monthly driving review, drivers' ranking, and remaining lifetime of consumables. For example, we designed a spider chart that reviews a driver's driving history and describes the driver's driving capability in terms of fuel efficiency. We also designed a chart that forecasts future mileage and shows an optimal time to replace engine oil considering the driving pattern; if drivers have poor driving patterns in terms of engine oil condition, then oil replacement should be performed earlier than normal. We confirmed that we can design contents personalized for the customer through analytics of natural records on customers.

Likewise, the other projects focused on the use of natural records being archived. Project 2 used the driving data collected from commercial vehicles (bus, taxi, and truck) in a driving safety enhancement service, whereas Project 5 used the daily behavior data collected from smart devices for a wellness service. Projects 3 and 4 focused on the use of national health insurance database for health care and management.

From the perspective of the issues in Section 4, starting from natural records saves effort in collecting the right data for service (Issue 1); but selection and integration of the right data is an essential issue of using natural records to advance service (Issue 5). As for Issue 8, the use of natural records contributes to searching for information content for customers from data. Since data were collected already, sensitive issues in using natural records include the quality management of data for service (Issue 3), planning data analytics for service (Issue 4), protecting the customer privacy in using their data (Issue 7), and mediating the different stakes of data-related stakeholders for service (Issue 11).

We do not think newly emerging data can replace traditional data such as the voice-of-the-customer and ethnographic data in existing service design approaches (e.g. Bettencourt, 2010; Patrício *et al.*, 2011). Rather, new data complement traditional data as they show different aspects of customers and customer concerns. For example, survey data represent customer perception, observation data represent customer behaviors exposed to

the researchers under a research question, whereas sensor data collected from consumer electronics (e.g. automobile and smart devices) represent customer behaviors naturally recorded in a quantitative format (e.g. GPS, time, and frequency). Thus, we believe all types of data are valuable and data-use for service can be improved as the variety of available data increases.

We confirmed the utility of combining existing customer analysis methods and newly emerging customer-related data through our projects. For example, at the beginning of Project 1, we drew a job map (Bettencourt and Ulwick, 2008) of driving to identify the needs of customers and analyzed the voice-of-the-customer archived in a database of customer complaints about their cars. This effort at problem diagnosis helped us develop an initial understanding of customers before doing any analytics on available data. We could understand the various aspects of people's driving processes by combining different data and methods and we believe such a combination is the best method in many cases. Thus, we call for more research that combines traditional customer data collected through inquiries and observations with newly emerging natural records that reflect real behaviors and contexts of customers.

### *5.2 Use of customer process-related data collected through sensors*

Studies on use of customer process-related data are required to advance service with data effectively. Though there are ever increasing types of newly emerging natural records, such as system condition data and text data in the internet, we found that the use of customer process-related data collected through sensors had a great potential for service advancement and management. Various studies have focused on the processes performed by customers to understand customers and design services for them. Payne *et al.* (2008) define a customer process as "a series of activities performed by the customer to achieve a particular goal" and state that customer value is co-created based on continuous interactions between customer and supplier processes through encounter processes. A job can be defined as "the fundamental problem that a customer needs to resolve in a given situation" and reflects the true customer need (Christensen *et al.*, 2007). All jobs involve processes, and understanding and managing a customer's processes for accomplishing a job is the key to innovating products and services (Bettencourt and Ulwick, 2008). As such, researchers often use a customer process-oriented perspective for their research; for instance, the key success factor of servitization in manufacturing is to focus on customer processes related to products (e.g. managing efficient document-related processes rather than selling printers, copiers, and supporting products) (Reinartz and Ulaga, 2008) and the ability to flexibly accommodate the customer processes in dynamic contexts is the key to value creation (Brozovic *et al.*, 2016).

A limitation in implementing customer process-oriented thinking for service advancement was the lack of customer process-related data. A challenge in understanding customer processes is the collection of a sufficient amount of process-related data from target customers. Researchers have used voice-of-the-customer and customer behavioral data collected through surveys and ethnographic research (e.g. Bettencourt, 2010). However, these methods are limited to reflect the real customer processes in that the data are collected mainly in an experimental setting that inherently involves a bias from the research hypothesis. In addition, these methods are often time-consuming and it is difficult to collect a large amount of data though customer process analysis requires numerous data in time or frequency domain.

Sensor data accumulated over time indicate characteristics of a specific process of the data source. We found that the use of sensor data collected from electronics is a great method for understanding individual customer processes that complements existing methods (Banaee *et al.*, 2013). For example, Project 1 started from an existing large vehicle-related database that archives big data collected through sensors of 18,943 vehicles. In this project,

the database reflects reality, and we tried to develop an understanding of the customers' driving processes. The process of data collection from people through their consumer electronics equipped with sensors has evolved to a considerable extent (e.g. driving data in Project 1 and daily behavioral data in Project 5). The variety and amount of data that can be collected from individuals will continue to increase (e.g. new collection of emotional and psychological data). These advances will contribute to the unlocking of the limitation of process-oriented thinking for actual service applications to customers.

From the perspective of the issues in Section 4, customer process-related data are the right data for service (Issue 1), contributing greatly to identifying the information useful to customers (Issue 8). For example, in Projects 3 and 4, one of the factors customers liked most about the new services was that data from their behavioral processes were transformed to feedback information to modify their behaviors (Issue 9). This factor is a key difference that distinguishes the use of customer process-related data for service and traditional data use, such as loyalty research, market investigation, and simulation. Customer processes are in fact a part of service value creation processes (Payne *et al.*, 2008). In addition, sensor data record customer behaviors spontaneously (Issue 2), the data quality is generally high and effectively managed by the sensor technology (Issue 3), and data analytics techniques used for industrial process management can be adapted, such as the mileage forecasting in Project 1 (Issue 4). On the other hand, protecting the customer privacy in using their process-related data (Issue 7) is a sensitive issue.

### *5.3 Understanding of data-based value creation mechanisms*

Studies on data-based value creation mechanisms are required to advance service with data effectively. The fundamental aspect of recent and expected data-use for service innovations is not IT, data, or products, but new methods for value creation. A value creation mechanism refers to a set of activities and resources, used by service customer and provider to jointly perform particular functions (Payne *et al.*, 2008; Lim *et al.*, 2012). A prerequisite to improve existing services or design new services for customers is a fundamental understanding of the value creation mechanisms in the context of the specific service in question (Patrício *et al.*, 2011; Lim and Kim, 2014). Service researchers have discussed the notion of value co-creation intensively (e.g. Vargo and Lusch, 2004; Galvagno and Dalli, 2014). However, with the exception of Saarijärvi (2011) and Saarijärvi *et al.* (2014), our review of the literature revealed a surprising lack of work directed at providing frameworks to help organizations manage data-based value creation or co-creation, despite its significance in the data-rich service economy.

In the context of services that use customer data intensively, customer data are converted into information that is usable by customers during value creation (Saarijärvi, 2011). As Figure 3 indicates, data-based value creation in such services involve several activities (Lim and Kim, 2014; Opresnik and Taisch, 2015) (e.g. collection of data about customer behaviors) and resources (Raghupathi and Raghupathi, 2014) (e.g. data analysis system). Figure 4a shows the data-based value creation mechanism identified in Project 1. The figure categorizes the customer's problems in the driving processes into vehicle condition and operations problems. The problem prevention mechanism involves the use of vehicle condition and operations data and the delivery of vehicle health management (VHM) and vehicle operations management (VOM) services. Likewise, the data-based value creation mechanism of preventive healthcare services presented in Figure 4b was used in Project 4. These figures were useful to identify the problem space, usage of available data, and service design scope in the projects; Project 1 focused on designing VHM and VOM services to improve the driving processes of the customers, whereas Project 4 focused on designing preventive services for healthy living.

In using a certain set of data (e.g. vehicle operations and condition data) for a business purpose, various directions can be taken (e.g. identification of sources of poor quality of the

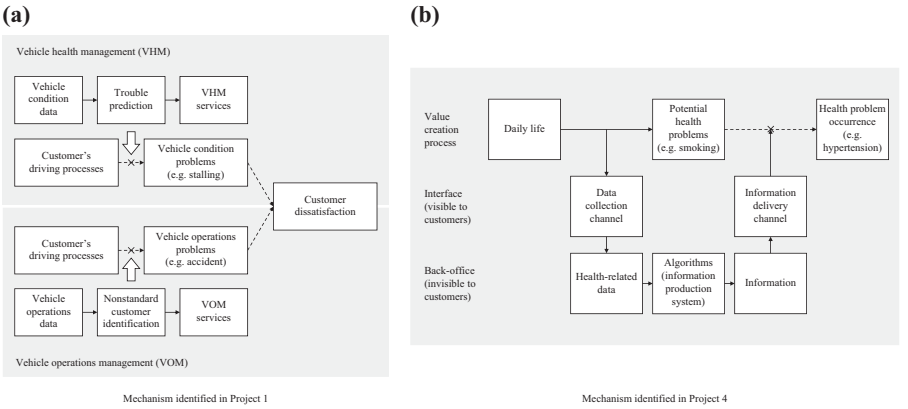


**Figure 4.**
Mechanisms of data-based value creation identified in projects 1 and 4

vehicle and establishment of a strategy for new vehicle design) and all of the distinct pieces of data collection, integration, management, and analysis activities become organized depending upon the direction. Thus, a prerequisite to using data to advance service is to define directions or themes of the services to be designed and to identify the requirements of data, data analysis system, and so on that will enable the services in question. The effectiveness and efficiency of using data to advance a service can be increased considerably when data-related activities are coherently oriented toward ultimate value creation. Thus, clear definition of the data-based value creation mechanism in question is crucial in advancing service with data.

From the perspective of the issues in Section 4, we observed from our projects that clear understanding and definition of data-based value creation mechanisms serves as a basis for effective data-use for service in terms of addressing the issues of (1) determining the right data for value creation by customers and providers alike (3) assessing the quality of data in terms of its usefulness to creating or enhancing value (4) analyzing data to understand the (potential) problems of customers (5) identifying data sources related to the value creation (8) identifying the information useful to customers for managing and improving their goal achievement, and (11) interpreting the different stakes to facilitate value creation.

### *5.4 Management of the customer experience about data and information*

Studies on the customer experience about data and information are required to advance service with data effectively. Aside from utilitarian functions, creating experiences and emotionally appealing moments matter to customers (Pine and Gilmore, 1999; Lemke *et al.*, 2011). Attention to customer experience is also important in the context of intensive data-use. In particular, it is important not to provoke customers in terms of privacy (e.g. where they drove) and burden (e.g. time to record data). In addition to the utility of information provided for customers, from our action research we confirmed findings from existing studies that the data collection device should be aesthetically pleasing and should provide a natural user interface for data collection (Zapata *et al.*, 2015); the use of data should consider the customer privacy (Casaló *et al.*, 2007; Akter *et al.*, 2013); the visualization of information content should be clear as well as rich (Orth and Wirtz, 2014; Choe *et al.*, 2015; Stoyanov *et al.*, 2015); and the service delivery process should be enjoyable to customers overall (Zomerdijk and Voss, 2010). For example, in Project 1, we designed various types of information content that can motivate customers to improve their driving behaviors, such as the comparison of a customer's eco-driving capability

with that of other customers. Similarly in Project 4, the cloud family doctor service assesses the healthy level of people and provides simple "suggestions" for health enhancement such as daily exercise and eating goals. The hypertension management service designed in Project 3 provided a short message to potential patients first and calls them to gently warn them about their potential hypertension onset and to encourage them to visit a local public health center.

We observed from our projects that the customer experience in a data-based service can be enhanced by addressing the issues of (2) making data collection enjoyable to customers without causing much burden (6) considering the regulation issues that are against or complement their experience (7) addressing their privacy issues in advance (8) delivering essential information that are actually useful to them and not pushing too much information (9) providing incentives to enhance their information acceptance, and (10) designing a service delivery process that is comfortable to them.

*5.5 Management of the synergy and conflict between data-related service stakeholders*

Studies on the synergy and conflict between data-related stakeholders are required. The notion of stakeholders involved in service has been emphasized in the literature to design sustainable and workable services that create value for multiple stakeholders (e.g. Krucken and Meroni, 2006; Frow and Payne, 2011). The notion of stakeholders is also highly relevant with the notion of customer value constellation, which represents the customer value creation mechanism enabled by a network of multiple actors and their interdependent relationships (Normann and Ramirez, 1993) and is thereby useful in service design (Patrício *et al.*, 2011). As mentioned previously in Issue (11) in Section 4, data-use for service advancement involves various types of data-related stakeholders across the value chain for (big) data (Miller and Mork, 2013). For example, the stakeholders of health-related data include patients, doctors, government employees, and health-related device manufacturers. Their different stakes often create synergy (e.g. integration of health-related data from wearable devices and hospitals) and conflict (e.g. data ownership, accuracy of data analytics result, and privacy issues) in data collection, information creation, and delivery in services. Thus, facilitating value co-creation between different data-related stakeholders is important in the health industry (Pinho *et al.*, 2014).

As indicated by the ecological views of big data (Shin and Choi, 2015), we believe the art of service advancement with data lies in effective matchmaking among the concerns of different data-related stakeholders. For example, in Project 4, we constructed an implementation plan for each designed service to mediate the conflicts pointed out by the interviewed experts. In one case, an expert mentioned that the cloud family doctor service should start with simply "reviewing" the integrated data of personal health records of a customer (e.g. showing descriptive statistics of the data) without providing any possibly inaccurate healthcare information that might be controversial (e.g. showing the predictive or prescriptive information about a disease) and without invading the territory of doctors (e.g. showing a diagnostic message). The expert suggested emphasizing the value of service as a complement to existing healthcare services and evolving the service in a step-by-step manner after the service is accepted to multiple stakeholders. Similarly, Project 2 considered the different perspectives of bus drivers, citizens, transportation companies, and government to avoid potential conflict, while Project 5 analyzed the different stakes of students, student counseling center, IT company, and device manufacturers to create synergy.

We observed from our projects that creating synergy between stakeholders and minimizing the conflict are required to address the issues of (4) developing an accurate algorithm for service that satisfies rigorous stakeholders (e.g. doctors, scientists, engineers, and governments) (5) collecting and integrating rich data from different stakeholders

(6) minimizing regulatory conflicts between stakeholders and winning a synergetic stakeholder over to the service party (8) determining useful information to stakeholders other than the focal customers and creating new markets (9) enhancing information acceptance based on the authority or contribution from professionals (10) designing a service delivery process that is based on an appropriate partnership, and (11) addressing different stakes of the stakeholders.

### *5.6 Development of a multidisciplinary framework for using data to advance service*

Review studies are required for the integration and customization of existing theories and methodologies into a single framework for data-use for service advancement. Using data to advance service requires various types of expertise from engineering (data collection), information systems (data and information exchange), statistics (data analytics), marketing (customer value), and more. We observed from our five projects that the data-use requires a cross-functional team with members from various functional units, including planning, design, engineering, IT, statistics, and marketing; all the five projects had to involve various types of experts. We performed Project 1 with managers who had diverse backgrounds and with vehicle experts; Project 2 with transportation and mechanical experts; Project 3 with chronic disease experts and statisticians; Project 4 with doctors, public health scientists, data scientists, IT, business experts, and government employees; and Project 5 with IT experts, student counselors, and stress management experts.

In these projects, we found that numerous pieces of knowledge are available for data-use for service advancement but that these are scattered across different fields, such as electronic engineering, computer science, industrial engineering, and management. One of our challenges was to integrate and customize existing knowledge of different experts for the context of data-use for service advancement. The 11 managerial issues in Section 4 reflect the challenges experienced by the authors, practitioners, and interviewed experts. Such challenges are interdisciplinary in nature and difficult to be addressed by simple and individual adoption of existing knowledge. Interdisciplinary review studies are necessary to guide the combinatorial use of existing knowledge (e.g. Frost and Lyons, 2017; Sheng *et al.*, 2017). Such work can be used in service advancement projects with data-use to mediate among the different perspectives of the various parties involved, thereby enabling effective use of data. We believe our findings can serve as a basis for review studies.

## 6. Concluding remarks

This paper reports real-world lessons from practices and projects aiming to advance service with data. One contribution of our work is the development of a service-oriented framework for using data effectively to advance service. The Internet of Things (Atzori *et al.*, 2010), big data analytics (George *et al.*, 2014), cloud computing (Iyoob *et al.*, 2013), smart service (Maglio and Lim, 2016), and autonomous service concepts (Maglio, 2017) are all highly relevant to the use of (big) data for service, which is increasingly important in the modern data-rich economy (Ostrom *et al.*, 2015). However, managerial issues in the use of these concepts for service advancement are not well known (Watanabe and Mochimaru, 2017). Rather than exploring individual points on the spectrum of using data to advance service, our study focused on a high-level view. The set of 11 issues provides a simple yet comprehensive framework for understanding and managing data-use in advancing service. In addition, we identified six items for future research to address the issues and to improve practice. The set of six research items could serve as an empirically identified basis for theory development. We believe this effort at developing holistic understanding will improve data-based service management in practice and contribute to synergy among different research fields across the managerial issues and research items.

In summary, we can integrate our findings into the service design process in Figure 2. In the preliminary investigation and customer understanding (Step 1), a service-oriented perspective (e.g. Issue 1) should be adopted to collect the right data for service and to integrate insights from the investigation into a single framework; here, customer process-related data collected through sensors can be used to understand customers by complementing the use of customer survey and observation data (i.e. Sections 5.1 and 5.2). In the service idea generation and refinement (Step 2), the mechanisms of data-based value creation should be identified as a basis for ideation (i.e. Section 5.3); the ideation should not only consider the utilitarian aspect of data-use but also its experiential aspect; a service-oriented perspective (e.g. Issue 4) should be used in analyzing data to come up with service ideas that can be realized based on the data; a data-oriented perspective (e.g. Issue 3) should be used to validate the ideas in terms of the maturity of data and data analysis; and synergy between stakeholders should be sought in ideation and the conflicts should be minimized through idea evaluation (i.e. Section 5.5). In the service concept and delivery process design (Step 3), the customer experience about data and information must be considered to design enjoyable services (i.e. Section 5.4); a service-oriented perspective (e.g. Issue 8) should be adopted in using data to enrich service concepts and delivery processes; a data-oriented perspective (e.g. Issue 6) should be used to design workable service concepts and delivery processes; and synergy between stakeholders should be created in the production and delivery of designed services. In the validation and implementation issue identification (Step 4), the customer experience must be considered for validation and customer-related issue identification; a data-oriented perspective should be adopted to validate if the designed services will operate well; conflicts between the stakeholders of the designed services must be minimized. The entire process of using data to advance service should be conducted by a cross-functional team to achieve an effective, efficient, and valid service design (i.e. Section 5.6).

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## About the authors

Chiehyeon Lim is an Assistant Professor in the School of Management Engineering at Ulsan National Institute of Science and Technology (UNIST). He obtained his BS Degree (2009) and PhD Degree (2014) from the Department of Industrial and Management Engineering at Pohang University of Science and Technology (POSTECH) (Advisor: Professor Kwang-Jae Kim). As part of his post-doctoral experience, he served as an Assistant Project Scientist and a Lecturer in the School of Engineering at the University of California, Merced (Advisor: Professor Paul Maglio). His research interests include smart service systems, service operations management, and general data analytics and decision science. Chiehyeon Lim is the corresponding author and can be contacted at: chlim@unist.ac.kr

Min-Jun Kim is a Researcher in the Samsung Electronics. He obtained his BS Degree (2011) from the Department of Industrial Engineering at the Hanyang University, Korea and PhD Degree (2017) from the Department of Industrial and Management Engineering at the POSTECH. His research interests include data-driven design of services and new product/service development.

Ki-Hun Kim is currently a PhD Candidate in the Department of Industrial and Management Engineering at the POSTECH. He obtained his BS Degree (2012) from the same department. His research interests include data-driven service, healthcare service, smart service system, and design of data-driven service.

Kwang-Jae Kim is a Professor in the Department of Industrial and Management Engineering at the POSTECH. He obtained his BS Degree from the Seoul National University, MS Degree from the KAIST, and PhD Degree in Management Science from the Purdue University (1993). His research interests include quality engineering, new product/service design, service engineering, and smart healthcare. His work has been applied in various areas, including semiconductor manufacturing, steel manufacturing, automobile design, and telecommunication and IT services. His research has been supported by various governmental agencies and industrial companies including Ministry of Education, Ministry of Science and Technology, Samsung, LG, POSCO, Hyundai, and IBM. He is the past Chairman of KIIE Service Science Research Group and serves as a Vice-President of the Society of Service Science (SoSS). He is a Member of IIE, ASQ, INFORMS, APIEMS, KIIE, KORMS, and KSQM.

Dr Paul P. Maglio is a Professor of Technology Management in the School of Engineering at the University of California, Merced. He holds a BS Degree in Computer Science and Engineering from the MIT and a PhD Degree in Cognitive Science from the UCSD. One of the Founders of the field of service science, Dr Maglio is currently Editor-in-Chief of INFORMS *Service Science,* and was the Lead Editor of the *Handbook of Service Science* (Springer).