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Strategic Management of Cloud Computing Services: Focusing on Consumer Adoption Behavior

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***Abstract*—The emergence of cloud computing services has led to an increased interest in the technology among the general public and enterprises marketing these services. Although there is a need for studies with a managerial relevance for this emerging market, the lack of market analysis hampers such investigations. Therefore, this study focuses on the end-user market for cloud computing in Korea. We conduct a quantitative analysis to show consumer adoption behavior for these services, particularly infrastructure as a service (IaaS). Bayesian mixed logit model and the multivariate probit model are used to analyze the data collected by a conjoint survey. From this analysis, we find that the service fee and stability are the most critical adoption factors. We also present an analysis on the relationship between terminal devices and IaaS, classified by core attributes such as price, stability, and storage capacity. From these relationships, we find that larger storage capacity is more important for mobile devices such as laptops than desktops. Based on the results of the analysis, this study also recommends useful strategies to enable enterprise managers to focus on more appropriate service attributes, and to target suitable terminal device markets matching the features of the service.**

***Index Terms*—Bayesian method, cloud computing, infrastructure as a service (IaaS), mixed logit model, multivariate probit (MVP) model.**

I. Introduction

THE new IT termed "cloud computing" is rising in popularity at a rapid rate. For example, Apple's iCloud service allows consumers to synchronize the movie they were watching across smartphones, desktops, and TVs and download their own data without physical memories such as flash drives. Similarly, Google Docs allows online consumers to use word processors or spreadsheets without purchasing or installing these programs. The recent emergence of smartphones, tablet PCs, and smart TVs has raised public interest in cloud computing services. Gartner, Inc.[1] identified cloud computing as the top ten strategic technologies for 2011 and Yoon [1] noted that global information technology (IT) enterprises such as Google, Amazon, Apple, and Microsoft intend to invest significantly in new cloud computing projects as a future core business. Market research institutions are bullish on such prospects and predict positive outcomes for cloud computing. According to Lee [2], the worldwide market size of cloud computing is expected to increase from USD 152 billion in 2011 to USD 343 billion in 2014. In particular, the mobile cloud computing market, which is closely related to the smartphone market, is forecast to expand substantially. According to ABI Research [3], the application market for the mobile cloud is expected to increase from USD 0.4 to 9.5 billion between 2009 and 2014.

One of the features of cloud computing services is that a terminal device is always required to access a cloud. The recent appearance of new portable devices and novel wireless communication standards like long-term evolution and world interoperability for microwave access has enabled the shifting of the main data network terminal from desktops to portable devices, such as smartphones, tablet PCs, and netbooks. Hence, special attention is now being paid to terminal devices in the cloud computing market.

Despite this growing market, however, there is scarce analytical research on cloud computing. Of the available literature, some studies provide an overview of cloud computing services without offering specific managerial implications. For instance, Wang *et al.* [4] review recent technological issues with cloud computing services and assess its key features and enabling technologies. Similarly, Qian *et al.* [5] outline a brief history of cloud computing and discuss its advantages and disadvantages as well as current issues related to the value chain and the standardization of services. Finally, Rimal *et al.* [6] suggest a cloud computing taxonomy that may assist academics, developers, and researchers and provide a brief comparative study of current cloud computing services in business. Rimal *et al.* [6] suggest a cloud computing taxonomy that may assist academics, developers, and researchers and provide a brief comparative study of current cloud computing services in business. Moreover, some recent studies also focus on consumer cloud services. Weiss *et al.* [7] develop a maturity model of consumer cloud computing to optimize the benefit from cloud computing services. Lansing *et al.* [8] empirically identify the most and least preferred trust assurance for consumer cloud services by using the best–worst scaling method. Finally, Naldi and Mastroeni [9] analyze the unit price for each cloud storage service of major providers and compare pricing plans. However, the market analysis on this topic continues to be scarce.

A handful of studies have investigated certain managerial and economic approaches that may be beneficial to the cloud computing industry. Regarding managerial research, Marston *et al.* [10] identified some issues pertinent to the cloud

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[1]Gartner homepage (http://www.gartner.com/it/page.jsp?id = 1454221).

computing business and key future players in this industry. Kushida *et al.* [11] suggested a conceptual framework to identify future aspects of the cloud computing market. In addition, Kim [12] conducted a qualitative consumer analysis. His research revealed that consumers regard availability and security as the most important attributes while selecting a cloud computing service. Regarding the economic perspective, Etro [13] analyzed the European cloud computing industry using a macroeconomic approach.

Our study shares some similarities with some of the research reviewed here. For instance, Behrend *et al.* [14] analyzed the adoption behavior for cloud computing using the technology acceptance model. However, they focused on the perceptions of consumers, rather than the preference for technical attributes of cloud computing. Anadasivam [15] also performed a conjoint survey on the cloud computing market to analyze consumer preferences, but terminal devices were not part of the study. Although there have been several studies on consumer adoption behavior in the cloud computing market, to date, there has been no approach focusing on the preference of the average consumer for cloud computing services, and the relationship between terminal devices and the cloud service markets.

The goal of this study is to find the most critical factor in the adoption of a cloud computing service from the perspective of the end-user's preference. To achieve this goal, we use the conjoint survey method and discrete choice analysis so as to derive the relative importance and willingness-to-pay of each attribute of the cloud computing service. In addition, we also analyze the correlation effect between each terminal device and cloud computing service, and show which terminal device is better matched with a certain cloud computing service based on the results of consumer adoption behavior. Using these analyses, we then suggest some managerial strategies to service providers concerning the kinds of cloud computing services that are likely to become popular in the future, and the varieties of terminal device markets they should focus on.

The remainder of this study is organized as follows. Section II explains an overview of the classification and definition of cloud computing services. Section III briefly explains the core methodologies used in the analyses. Section IV presents conjoint analysis and describes the survey data collected by conjoint method. The result of the analysis of consumer preference and the correlation between terminal devices and services is shown in Section V. Finally, Section VI discusses the implications and conclusions of this study.

II. Definition and Classification of Cloud Computing Services

Despite the various definitions of cloud computing service by institutions, enterprises, and researchers, there is no consensus about academic or practical definition. Buyya *et al.* [16] propose that "a *Cloud* is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers." Gartner, a market research institution, defines cloud computing as "a style of computing where massively scalable IT-enabled capabilities are delivered "as a service" to external customers using Internet technologies" [17]. The concept that cloud computing is delivered to a consumer "as a service" is crucial to its classification. This notion implies that the major advantage of using cloud computing is that it enables users to access an infinite resource of the service provider's server, with something as simple as a smart device, which has a very limited capacity.

Cloud computing services can be classified into three categories according to the types of services offered. Mell and Grance [18] suggested this taxonomy after collating separate existing ideas and it is fast becoming a standard classification, both in the academic and the industrial world. The first category in this taxonomy is "software as a service" (SaaS). SaaS is a service that enables consumers to use each type of software through online payments to the cloud service provider. With SaaS, users do not need to purchase or even borrow the software. "Google Docs" and "Microsoft Office Live" are good examples of SaaS. The second category is "platform as a service" (PaaS). PaaS is a service for program developers who suffer from a lack of network resources and tools. PaaS such as "Google AppEngine" and "Windows Azure" offers a well-formed program development environment at a reasonable price. "Infrastructure as a service" (IaaS) is the last category of cloud computing. IaaS provides users with a wide variety of interfaces and abstractions including the ability to dynamically provide entire virtual machines such as servers, storages, and central processing units owned by the service provider [19]. Through IaaS like Amazon EC2 and S3, consumers can, thus, use a substantial amount of resources without purchasing them.

Since this study focus on general end users, a service aimed at a specific group, such as PaaS, is not an appropriate object for this study. In addition, to analyze the correlation between various terminals and services, the object of this study should be a service that is easily accessible from mobile devices. Given that Christensen [20] noted that the most obvious use of cloud computing is probably in mobile applications, we select the cloud storage service as the object of this study. Moreover, because the price of IaaS is determined by the consumer usage pattern of the cloud storage service [21], price elasticity of IaaS should be analyzed to provide managerial direction to enterprises. Additionally, an analysis of the cloud storage service would provide some advantages toward deriving willingness-to-pay for resource delivery. This reasoning helped us choose the appropriate research objects for the consumer analysis.

There are many cloud storage services available on portable devices, such as mobile devices and tablet PCs. For instance, Bdrive, Dropbox, and Skydrive from Microsoft are in service globally, while Ndrive of NHN, 2ndDrive of Nowcom, and DaumCloud are popular in South Korea.

III. Model Specifications

This study analyzes consumer adoption behavior of the IaaS cloud computing service as well as the relationship between the

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cloud computing service and terminal devices, in order to provide managerial strategies toward improving product development and marketing planning. Accordingly, the analysis model of this study is divided into two parts. The first part estimates consumer preference in terms of core attributes of the cloud computing service, and analyzes both marginal willingness-to-pay (MWTP) and the relative importance of core attributes. The second part then analyzes the relationships between the cloud computing service and terminal devices.

Let us view the model for estimating consumer preferences for the cloud computing service. We use the random coefficient discrete-choice model, called the mixed logit model in order to accommodate the heterogeneity of consumer preferences. A mixed logit model based on random utility theory assumes that each consumer i has his or her own utility function for each product or service j in choice set t [22], [23]. The utility function is stated as follows:

$$U_{ijt} = V_{ijt} + \varepsilon_{ijt} = \sum_{k} \beta'_{ik} X_{jkt} + \varepsilon_{ijt}. \tag{1}$$

This utility function distinguishes the effects from deterministic factors V_{ijt} and random factors ε_{ijt}. The deterministic part consists of the marginal utility β_{ik} of each attribute k of service j, and the vector X_{jkt} of each attribute. In contrast to other discrete choice models, a mixed logit model allows for the stochastic nature of marginal utility β in order to assume the heterogeneity of each consumer's preference. In this model, β_{ik} is set to a vector that follows the multivariate normal distribution with a mean of b_k and a covariance matrix of Σ_k, i.e., $\beta_{ik} \sim N(b_k,\ \Sigma_k)$ and ε_{ijt} is assumed to be a random disturbance following type 1 extreme value distribution. From these assumptions, the likelihood function for each consumer can be derived as follows:

$$L(d_i\,|\beta_i) = \left(\prod_{t=1}^{T} \frac{e^{\sum_k \beta'_{ik} X_{jkt}}}{\sum_{l=1}^{J} e^{\sum_k \beta'_{ik} X_{lkt}}} \right) \tag{2}$$

where d_i represents the choice result made by consumer i in $T \times J$ alternatives.

Even if we were to derive this likelihood function, it would be too complicated to estimate each parameter using classical methods. Hence, this study uses the Bayesian estimation method to overcome this problem. Bayesian estimation provides some advantages by avoiding the complicated integration of multivariate density function, and overcoming the initial point problem and the global optimal solution problem [24]–[26]. Moreover, the result from the Bayesian estimation can also be converted into a classical estimation result [27].

To provide economic meaning based on the results of each coefficient, we derive the MWTP of each attribute k from the samples drawn in the Bayesian inference process. For N drawn samples, the MWTP can be calculated as follows:

$$\begin{aligned} \text{Median MWTP}_k &= \text{Median}_i \left[-\frac{\partial U_i/\partial x_i}{\partial U_i/\partial p_i} \right] \\ &= \text{Median}_i \left[-\frac{\beta_{ik}}{\beta_{i(\text{price})}} \right]. \end{aligned} \tag{3}$$

The second part of the model estimates the relationships between cloud computing services and terminal devices. Consumers typically choose from among multiple alternatives at the same time, which necessitates the development of a multivariate discrete choice model such as a multivariate probit (MVP) model [24]. We prefer the MVP model to the multivariate logit model, which assumes the independence of irrelevant alternatives [23], too strong assumption for our research objective. The utility function of consumer i for device or service j in the MVP model is as follows:

$$\begin{aligned} U_{ij} &= \beta' X + \varepsilon_{ij} = \gamma_j + \sum_{d} \beta'_{jd} S_{id} + \varepsilon_{ij} \\ Y_{ij} &= \begin{cases} 1\,\mathrm{m} & \text{if } U_{ij} > 0 \\ 0, & \text{if } o.w \end{cases} \end{aligned} \tag{4}$$

where γ_j is termed the alternative specific constant (ASC) of each product or service j.

We introduce the sociodemographic variable S_{id} for each sociodemographic indicator d, such as gender, age, income level, and education level. In the MVP model, the disturbance ε_{ij} is assumed to follow a multivariate normal distribution with zero mean and variance–covariance matrix Ω. The choice probability that consumer i chooses multiple alternatives is as follows:

$$P(Y_i|\beta, \Omega) = \int \cdots \int \phi_J \left(\varepsilon_{i1}, \ldots, \varepsilon_{iJ} \,|0, \Omega \right) d\varepsilon_{i1}, \ldots, d\varepsilon_{iJ} \tag{5}$$

where $\phi_J \left(\varepsilon_{i1}, \ldots, \varepsilon_{iJ} \,|0, \Omega \right)$ is the J-variate normal density function with zero mean and variance–covariance matrix Ω.

For estimation, this study also uses the Bayesian estimation technique to derive the estimation result of Ω and β.

IV. Survey and Data

This study uses the conjoint survey method in order to collect the stated preference data about consumer adoption behavior of cloud computing services and terminal devices. This method uses cards listing various alternatives of the different product/service attributes, so as to provide respondents with the more realistic context of evaluating potential product profiles. With the conjoint survey, a researcher can analyze consumer preference for any product/service from a combination of core attributes [28], [29]. The conjoint survey method has been utilized as a general tool for market evaluation of new products and market segmentation, and is highly useful as it can also be combined with econometric models such as the consumer utility model for consumer analysis of new product markets [30]–[33].

We collected the survey data from 400 respondents aged from 20 to 60 in April and May 2011. The survey was conducted by a specialist survey company. Interviews were carried out on a one-to-one basis because this approach provides reliable data. Interviewees were selected by random sampling using the purposive quota sampling method. The demographic characteristics of the sample are shown in Table I.

The following six core attributes were selected for analyzing consumers' preferences toward cloud storage services: "service fee," "service provider," "storage capacity," "maximum file size for upload," "maximum number of devices that can be

TABLE I
DEMOGRAPHIC CHARACTERISTICS OF THE SAMPLE

		Respondents	Percentage
Total		400	100%
Gender	Male	198	49.5%
	Female	202	50.5%
Age (years)	20–25	33	8.25%
	26–30	75	18.75%
	31–35	47	11.75%
	36–40	69	17.25%
	41–45	52	13%
	46–50	54	13.5%
	51–55	54	13.5%
	56–60	16	4%

TABLE II
ATTRIBUTES AND ATTRIBUTE LEVELS

Attribute	Explanation	Level
Service Fee (KRW 10 000)	Monthly fee as a lump sum payment for using the cloud storage service	Free
		0.5
		1
		2
Service Provider	The service provider hosting the cloud storage	Internet Service Provider (ISP)
		Web Portal Service Provider (WPS)
Storage Capacity	Maximum storage allocated to each user	20 GB
		300 GB
		1 TB (1000 GB)
Maximum File Size for Upload	The maximum size of a single file that can be uploaded to the cloud	0.5 GB
		2 GB
		4 GB
Maximum Number of Devices That Can Be Synchronized	The maximum number of devices that can be synchronized with the cloud	2
		5
Stability	The probability of disconnection or malfunction while using the service	0%
		1%
		2%

Note: According to the Bank of Korea (www.bok.or.kr), USD 1 = KRW 1,159.60 in January 2012.

synchronized," and "stability." These attributes were selected practically in the light of actual IaaS provision in South Korea. For instance, the attribute "maximum number of devices that can be synchronized" was selected because the average number of possessing device is increasing, implying the greater usage of cloud computing on various portable devices. Therefore, this attribute is essential in order to assess how the growing use of mobile devices influences the cloud computing service market. Further, "stability" was selected in line with the findings of Armbrust *et al.* [34], which stated that one of the obstacles for the diffusion of cloud computing service is its service availability, or in other words, its stability. "Service provider" is necessary in order to understand the effect of other possible attributes such as security and the speed of synchronization. It is assumed that Internet service providers (ISP) provide better quality connections but lack security, whereas web portal service (WPS) providers offer more secure protection but depend on ISPs for the quality of their network connection. Table II shows selected attributes and the levels of each attribute. These attributes are set to have nonlinear levels in order to vary the intervals and cover sufficient ranges to make the choice situation more realistic because each alternative is assumed to provide different level of utility. Further, the attributes are assumed not to be associated, even in case of price and storage capacity which are obviously associated in real life because the coefficient of each attribute must be independent of the alternative's type [35]. The total number of possible alternatives using these attributes and levels was 432.[2] However, such a large amount of alternatives should be reduced to a practical size in order to release the burden on respondents. Hence, a fractional factorial design was used herein, which is a fraction of the full factorial design that allows researchers to create a conjoint design that is small and ideally sized and suggest alternatives orthogonal to each other [36]. Altogether, 16 optimal alternatives were obtained using statistical product and service solutions (SPSS) and from this, four sets of four cards were formulated. The respondents selected the most preferred alternative from four alternatives of each choice set. Please see Appendix A for the details of 4 sets and 16 cards.

V. EMPIRICAL ANALYSIS

A. *Estimation Results for Consumer Preference of Cloud Computing Services*

For the presented estimation process, we use the Bayesian estimation method with Gibbs sampling. To remove the effect of the initial points from the estimation process, the first 10 000 draws, considered as the burn-in period, are discarded from the 20 000 draws generated through the Bayesian estimation process. In the remaining 10 000 draws, every tenth draw is retained in order to estimate the coefficients (i.e., 1000 draws). Given that the estimated coefficients from the retained 1000 draws will be interpreted from the Bayesian perspective, we extract 2000 draws from the distribution of estimation parameter for the traditional perspective interpretation. Thereafter, we estimate the mean and variance of β using these 2000 draws.

Further, because the consumer utility for cloud storage services reflects only a relative preference for attributes, this study analyzes the MWTP of the six core attributes and finds the economic meaning using (3) as well as the average relative importance[3] of each attribute. The results are shown in Table III.

The results presented in Table III show that all six attributes are significant except for the "maximum number of devices that can be synchronized." Because smart devices such as portable terminal devices are not sufficiently distributed to consumers and the need to synchronize more than two terminal devices is weak from the consumer perspective, the effect of the number of possible synchronized devices is not significant. Indeed, according to the Korea Internet & Security Agency (KISA)

[2] $432 = \Pi$ (number of levels of each attribute) $= 4 \times 2 \times 3 \times 3 \times 2 \times 3$.
[3] According to Kim *et al.* [33], the average relative importance of each attribute is calculated as follows:

$$\text{Average Relative Important Percent of Attribute } k = \frac{1}{N}\sum_{n=1}^{N}\left(\frac{\text{part} - \text{worth}_{nk}}{\sum_k \text{part} - \text{worth}_{nk}} \times 100\right)$$

where, $\text{part} - \text{worth}_{nk} = (\text{interval of attribute } k'\text{s level}) \times \beta_{nk}$.

TABLE III
ESTIMATION RESULTS

Attribute	Mean	Average Relative Importance (%)	Median Willingness-to-Pay
Service Fee	−6.074**	46.36	-
Service Provider	0.458**	6.1	KRW 832.3 for Subscribing to the ISP
Storage Capacity	0.582**	16.17	KRW 891.8 per 100 GB
Maximum File Size for Upload	0.604**	12.66	KRW 922.9 per GB
Maximum Number of Devices That Can Be Synchronized	−0.061	5.37	KRW 110.5 per Additional Synchronized Device
Stability Failure	−1.323**	13.35	KRW 2,153.1 per 1% Reduction in Disconnection and Malfunction
Likelihood Ratio Index	0.231		
Log-likelihood at zero	-2218.07		
Log-likelihood at convergence	-1706.21		

Note: **: Significant at the 5% level.

[37],[4] the average number of smart devices per Korean household is 0.71 (1.64 for households that possess smart devices).

The coefficient for "service fee" shows a significantly negative and high value. This result implies that consumers have a higher marginal utility for service charges, in line with the findings of Bhardwaj *et al.* [21], who show that most consumers are sensitive to the levels of IaaS pricing. For "service provider," which is defined as a dummy variable with WPS provider as the reference, we find that consumers prefer an ISP to a WPS. Consumer may expect that ISPs can provide better quality of connection guaranteeing fast synchronization, but WPSs cannot provide more secure protection from personal information leaks or faster synchronization than ISPs. In addition, the results related to size show that consumers prefer cloud storage services providing bigger storage and allowing larger file size uploads. For "stability," consumers do not significantly prefer cloud storage services with higher rates of disconnection.

According to the results for the relative importance of each attribute, the most important attribute for consumer selection of a cloud storage service is its service fee (46.36%). This result underscores the significance of computing the price of IaaS for the cloud computing service market. The second most important attribute for adoption of a cloud storage service is its storage capacity (16.17%). Given that the extent of direct benefit for consumers depends on the amount of resources allocated to them, the result for storage capacity in this study is reasonable. In addition, the relative importance of stability of the service is 13.35%. Because cloud computing services depend on a network, failure to connect to the network hampers use of the service, and becomes an obviously critical factor. Therefore, maintaining the stability of a cloud storage service is an essential factor for encouraging its uptake. Moreover, the relative importance of "maximum file size for upload" is 12.66%. Due to the popularity of high-quality movies and other videos available on the Internet, consumers put a premium on the availability of high-capacity service cloud providers rather than cloud storage services.[5]

Based on the results of MWTP for each attribute, consumers indicated a high MWTP for a stable service. On average, consumer MWTP for a stable service is KRW 2153 when chances of instability increased by 1%; on the other hand, consumer MWTP for storage capacity is KRW 892 when the storage capacity increased by 100 GB. This result indicates that consumers are willing to pay a higher price to maintain the stability of service even though stability is not of greater importance than storage capacity. One possible reason is that the cost of securing and maintaining a 1% more stable service would be higher than the cost of providing 100 GB more storage to each consumer. As Durkee [38] stated, highly reliable service is expensive and the cost of maintaining a reliable service increases geometrically as the 100% mark approaches. Moreover, Durkee also noted that consumers risk a high cost of downtime. Thus, consumers would regard high stability as a difficult aspect to secure, which is reflected in their WTP. In addition, stability is of greater importance in using cloud-based storage services than in using other cloud services such as SaaS. This is because in case of storage services, consumers risk the possibility of losing their in-progress data or the inaccessibility of their data when they need it, whereas in case of other services, they merely risk unavailability of the service.

In case of storage, the result shows that consumers would not mind paying KRW 8920 for 1 TB of storage service. Interestingly, there is no substantial difference between the results of this study for 1 TB of storage service and the real market price for 1 TB of storage service. Moreover, when the maximum file size for upload is increased by 1 GB, the average MWTP is KRW 923. Assuming that the size of high-quality movies and other such videos would not exceed 2 GB, consumers indicated an MWTP of KRW 1846 for this service.

B. *Estimation Results of the Relationship Between Services and Terminal Devices*

This section uses the MVP model to identify the kinds of cloud storage services that are more preferred for each terminal device. Before conducting the analysis, it is first necessary to classify cloud storage services into certain types. The previous section concerning analysis of consumer preference for cloud computing services showed that the top three important attributes are service fee, storage capacity, and stability (in that order). This means that consumers choose the best alternative based on the level of these three important attributes. For analysis in this section, we use 16 alternatives used in the conjoint

[4]KISA [37] surveyed 30 000 households in Korea and conducted one-to-one interviews between July and September, 2011. In this case, the stratified multistage cluster sampling method was used to extract the sample.

[5]This study also conducted a basic survey about the types of additional services consumer would like to avail of in the future. The 400 respondents who participated in the survey indicated that they would prefer video streaming services (35.5%), followed by music streaming services (25.8%), social networking services (13.3%), public ownership folder services (15.0%), and recovery services (10.5%).

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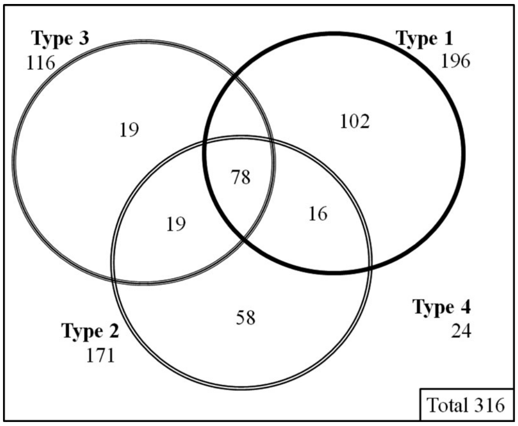

Fig. 1. Distribution by classification (type of cloud) of respondents who indicated that they would purchase one cloud service and select one alternative.

survey and classify them into four categories: "Type 1 cloud" includes cloud storage services with the lowest price (i.e., free). "Type 2 cloud" has the highest stability (i.e., zero disconnections). "Type 3 cloud" has the largest storage capacity (1 TB) and finally, "Type 4 cloud" includes the other type of services. These types except for Type 4 are not mutually exclusive; in other words, some cloud storage services are included in more than one classification. Because the MVP model used herein considers multiple-choice situations, these categories are, thus, deemed to be suitable for the analysis. In Appendix A, Table A1 shows how each card is classified into these types.

During the conjoint survey, respondents choose the best alternative among four alternatives in each choice set. Because there are four choice sets, respondents have four times choice situations. After this, we gathered the four best alternatives from each choice set and then asked respondents which alternatives could be purchased in practice. Altogether, 316 respondents chose one cloud storage service that they would purchase in practice, while the remaining 84 respondents would not purchase any services.[6] Using the classification of cloud storage services presented earlier, the distribution of 316 respondents by type of cloud is depicted as Fig. 1.

In addition, the effects of sociodemographic variables on the selection of cloud storage services and terminal devices are analyzed. We consider two models: Model A considers sociodemographic variables such as age, gender, education, and income, to investigate their effects on the selection of cloud services and terminal devices. Model B considers the ASC variable to analyze the average effect of each alternative. Gender is defined as the dummy variable, with "female" set as the reference. The results of this section are shown in Table IV.

First, the results of Model B show that the Type 1 cloud is most preferred. This result can be intuitively identified from Fig. 1, and it is consistent with the result of the mixed logit model concerning the high importance of price in the previous section. As far as terminal devices are concerned, the desktop PC is the most preferable terminal device when cloud storage services are used. The indicated preferences for the remaining terminal devices are smartphones, laptops, tablet PC, and netbooks, in that order. Due to the recent rapid diffusion of the smartphone, consumers prefer this device to the laptop.[7] Moreover, because the distribution rate of the tablet PC is still smaller than that of the laptop, Korean consumers prefer the latter to the tablet PC as a terminal device. However, this is likely to change as the growth rate of the tablet PC market will exceed that of the laptop market in the near future.[8]

TABLE IV
Estimation Results of ASC and Sociodemographic Variables

	Model A					Model B
	ASC	Gender	Age	Education	Income	ASC
Type 1 Cloud	-0.709*	0.154	0.003	0.053	0.000	-0.026
Type 2 Cloud	-0.268	-0.002	-0.005	0.021	0.001	-0.179**
Type 3 Cloud	-0.205	0.296	-0.015**	-0.009	0.003**	-0.531**
Type 4 Cloud	0.168	0.254	-0.005	-0.339**	0.000	-1.555**
Desktops	0.655	0.098	0.005	-0.061	0.000	0.576**
Laptops	-0.450	-0.040	-0.010†	0.014	0.000	-0.685**
Netbooks	-1.078	0.074	-0.001	-0.022	-0.002†	-1.880**
Tablet PCs	-0.256	0.123*	-0.017*	-0.027	-0.000	-1.530**
Smartphones	-0.136	-0.091†	-0.005	-0.011	0.000	-0.430**

Note: †: Significant at the 10% level, *: Significant at the 5% level, **: Significant at the 1% level.

Second, this study analyzes the effect of sociodemographic variables on the adoption of cloud services and terminal devices by using Model A. The results of Model A show that younger and higher income consumers significantly prefer Type 3 cloud services. This is probably because the Type 3 cloud offers larger storage capacity, which allows more various and wider usage of the cloud computing service and larger capacity is more necessary to advanced users. It is interesting that less educated people significantly prefer Type 4 cloud services. Considering that Type 4 clouds have no specialized attribute, it can be said that less educated people may not distinguish each attributes to make their preference and just prefer a normal one. On the other hand, there are no significant coefficients for other cloud types, as shown in Table IV. This result indicates that for other cloud types, there is no heterogeneity of consumers. In other words, the sociodemographic difference among consumers would not affect their choice of cloud type. For example, the preference for Type 1 cloud (free cloud services) would not differ between older and younger consumers.

The results of Model A show that males prefer the tablet PC as a terminal device. This is probably because male users tend to have a more favorable attitude toward new equipment compared to females. Since younger people also tend to favor new services and new products that promise higher mobility, it appears natural for younger consumers to prefer using tablet PCs and laptops as terminal devices. In addition, consumers from lower income groups prefer netbooks as terminal devices, probably due to their budgetary constraints.

[6]The details of survey process are shown in Appendix A.

[7]According to the International Data Corporation (www.idckorea.com), 2.66 million laptops were sold in Korea in 2010. The ROA Consulting Group (www.roagroup.co.kr) reported that the sales of smartphones in Korea touched 4 million during the same period.

[8]Socialnmedia (www.socialnmedia.co.kr) reported that the market share of the tablet PC in the United States in the first quarter of 2010 was smaller than that of the laptop and the netbook. However, they predicted that the market for the tablet PC will eventually encroach on the market for the other devices.

TABLE V
VARIANCE–COVARIANCE MATRIX

	Type 1 Cloud	Type 2 Cloud	Type 3 Cloud	Type 4 Cloud	Desktops	Laptops	Netbooks	Tablet PCs	Smart phones
Type 1 Cloud	1.000								
Type 2 Cloud	0.208**	1.000							
Type 3 Cloud	0.341**	0.737**	1.000						
Type 4 Cloud	-0.600**	-0.611**	-0.679**	1.000					
Desktops	-0.141*	-0.028	-0.112†	-0.026	1.000				
Laptops	-0.008	0.057	0.129†	-0.003	-0.322**	1.000			
Netbooks	-0.018	0.092	0.075	0.150	-0.460**	-0.069	1.000		
Tablet PCs	-0.061	0.083	0.079	0.107	-0.202*	0.034	0.165	1.000	
Smartphones	0.169*	0.037	-0.058	0.017	-0.517**	-0.224**	0.293*	-0.117	1.000

Note: †: Significant at the 10% level, *: Significant at the 5% level, **: Significant at the 1% level.

One of the benefits of using the MVP model is that it estimates the variance–covariance matrix Ω. The variance–covariance matrix reveals complimentary/substitute patterns between/among the cloud computing service and the terminal devices. However, the complimentary/substitute patterns shown in this study do not perfectly reflect the findings of classical economics about complimentary/substitute relationships. Rather, these results can be interpreted using the possibility theory. For instance, if $\mathrm{cov}(\varepsilon_j,\ \varepsilon_k) > 0$, consumers will choose both alternative j and alternative k, i.e., there is a higher probability of a simultaneous purchase. On the other hand, if $\mathrm{cov}(\varepsilon_j,\ \varepsilon_k) < 0$, it implies that the consumer will choose only one alternative, either j or k. In other words, it can be said that alternatives have a complimentary/substitute pattern for each other. The results of the variance–covariance matrix using Model A are shown in Table V.

The forthcoming analysis is divided into three parts: the relationships among cloud services, the relationships among terminal devices, and the relationship between terminal devices and cloud services. First, the results of the variance–covariance matrix in Table V show that there is a significantly positive relationship among Type 1, Type 2, and Type 3 clouds. This is because, as the results show, consumers who regard price as an important attribute also consider service stability and storage capacity to be essential attributes. By contrast, the Type 4 cloud has a significantly negative relationship with all other types of cloud services. This is because the Type 4 cloud is mutually exclusive to other types (see Fig. 1). In addition, this can also be interpreted from the perspective of preference. For example, while Type 1 clouds include only free cloud services, Type 4 clouds do not include any free cloud services. Thus, if consumers prefer Type 1, they would not choose Type 4 because these consumers make their choice only on the basis of service fee, irrespective of other attributes.

The results of the second part of the analysis show that desktops have negative relationships with all other terminal devices. Desktop consumers have low preferences toward mobile cloud services, which are mostly used outdoors. On the other hand, smartphones have a significantly positive relationship with netbooks. Consumers who regard mobility to be important have a desire to use cloud services by synchronizing with portable devices.

Finally, we examine the relationship between terminal devices and cloud services. Our results indicate that the Type 3 cloud has a significantly positive relationship with the laptop whereas it has a negative relationship with desktop. Because the laptop has relatively lower technical characteristics (such as storage capacity and speed) than the desktop PC, it is reasonable to expect that the Type 3 cloud with its advantage of technical attributes would partner well with portable devices like laptops. For the netbook and tablet PC, the direction of estimation results is similar to laptop, but not significant. In addition, the Type 1 cloud has a significantly positive relationship with the smartphone. This result indicates that consumers who use the smartphone as the terminal device prefer low price as an important attribute.

VI. CONCLUDING REMARKS

We conducted a wide-ranging analysis of cloud storage services to investigate consumer awareness of and preferences for specific service attributes. The results of this study show that consumers regard price and stability as must-be attributes. The relative importance of price and stability was recorded as 46.3% and 13.4%, respectively. Consumers also consider storage capacity as an important factor (16.2%). In particular, respondents who were younger and belonged to a high-income group significantly preferred this attribute over others. Moreover, cloud services offering higher storage capacities were found to have a positive relationships with portable devices such as laptops but negative relationships with desktops.

The results of this study provide important implications for IaaS service providers in terms of them offering a low priced and stable service to customers. For those cloud services known for their technical attributes, such as storage capacity, firms should focus on younger and higher income groups as target buyers. For example, they could target consumers by adopting a bowling alley strategy or bundle together the sales of cloud services and terminal devices such as smartphones and laptops. In addition, because certain consumers prioritize technical attributes over price, it is also a good marketing strategy to provide relatively high-priced or premium services. By contrast, mobile telecommunication companies servicing smartphones should maintain low prices for IaaS, as consumers using smartphones as terminal devices regard low pricing as an important attribute for such services.

This study also offers managerial implications because it is the first research to quantitatively analyze consumers'

TABLE A1
FOUR CHOICE CARDS USED IN CONJOINT SURVEY AND THE CLASSIFICATION OF EACH ALTERNATIVE

Card No.	Service Fee (1,000 KRW)	Service Provider	Storage Capacity (GB)	Maximum File Size for Upload (GB)	Maximum Number of Devices That Can Be Synchronized	Stability (%)	Classification used in MVP estimation
A1	0.5	ISP	20	2	2	2	Type 4
A2	0.5	WPS	300	0.5	2	1	Type 4
A3	Free	ISP	300	0.5	5	2	Type 1
A4	0.5	WPS	20	0.5	5	0	Type 2
B1	Free	WPS	20	4	5	1	Type 1
B2	1	ISP	300	4	2	0	Type 2
B3	1	WPS	1,000	0.5	5	2	Type 3
B4	2	ISP	1,000	0.5	2	1	Type 3
C1	0.5	ISP	1,000	4	5	0	Type 2, 3
C2	Free	WPS	1,000	2	2	0	Type 1, 2, 3
C3	Free	ISP	20	0.5	2	0	Type 1, 2
C4	2	WPS	20	4	2	2	Type 4
D1	1	ISP	20	2	5	1	Type 4
D2	2	WPS	300	2	5	0	Type 2
D3	2	ISP	20	0.5	5	0	Type 2
D4	2	WPS	20	0.5	2	0	Type 2

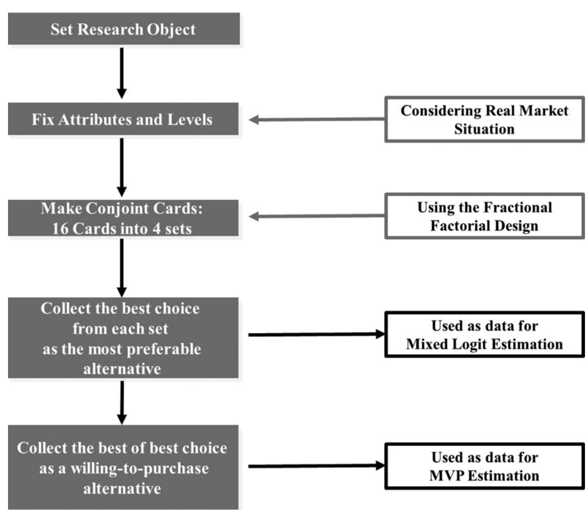

Fig. A1. Process of conjoint survey and relation to the each part of this study.

preferences toward cloud computing services. Moreover, in-depth research into consumer adoption behavior was possible through the analysis of consumer preferences, and the relationships between terminal devices and cloud services. However, we acknowledge that the scope of our research objective in this study is limited. Because SaaS are predicted to have the greatest effect on the cloud computing service market going forward, further market analysis of SaaS is necessary in order to examine both consumers' preferences and the relationships between terminal devices and cloud computing service. Further, examining the relationship between previous customer experience and choice of cloud computing service would provide interesting managerial implications such as the brand loyalty and technological expectations of consumers in this area. Finally, it would be helpful for future research to develop a new methodology based on integrated multiple stage estimation for analyzing the relationship between terminal devices and cloud computing services. Such an integrated model could provide a consistent coefficient for each service or product and reflect a consumer's decision-making process better.

APPENDIX A

The conjoint survey was conducted according to the process described in Fig. A1.

As shown in Fig. A1, two major questions were presented to respondents: "Which card of set A do you prefer?" and "Which card of your best choices do you intend to purchase in practice?" The 16 cards selected by the fractional factorial design are shown in Table A1. Table A1 also shows how each card was classified into each type.

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