An Analysis of Consumer Preferences among Wireless LAN and Mobile Internet Services

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Wireless data communication (WDC) services are increasingly penetrating the market. The two main alternative WDC technologies are wireless LAN and mobile Internet. Services based on these technologies display differences in quality attributes such as terminal device, data transmission speed, pricing scheme and so on. How consumers choose between these two alternatives will be determined by their preferences regarding such quality attributes. In turn, their preferences will affect the evolution of WDC services and related technologies. This study employs a conjoint analysis of consumer valuations of quality attributes of wireless LAN and mobile Internet services. Respondents rate hypothetical service alternatives featuring various combinations of quality attributes. By estimating consumer willingness to pay for the attributes of WDC services, the authors predict the evolution of WDC services and related technologies along various quality dimensions, make a comparison with the results of a previous study, and draw policy implications for national- and company-level R&D strategies.

Keywords: Wireless data communication, rank-ordered logit, Bayesian estimation.

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I. Introduction

Only 10 years ago voice communications occupied the major share of communications services, but the focus of communications services has since evolved from voice to data transfer via the Internet, which by the end of the 20th century had become widespread.

At the same time, the world has seen the advent and growth of wireless communications, in the form of mobile communications, which has had an immense economic impact on not only the mobile communications industry but also related industries such as the manufacture of equipment and component parts. Since the beginning of the 21st century, however, revenues of voice communication service providers have been on the wane due to a slowdown in the rate of increase of customers and falling call charges. Service providers have offered data communication services based on mobile communication networks as an alternative—known as mobile Internet in South Korea. However, the traditional revealed-preference analysis does not apply to the mobile Internet environment because the volumes of both data traffic and revenues are slight, as are their rates of increase.

Moreover, new wireless communications technologies such as wireless LAN and Bluetooth have appeared that present a competitive threat to incumbents. Accordingly, uncertainty about recouping returns on enormous investments in communications facilities has increased. In the mobile communications industry, the relative importance of data communications as opposed to voice communications is constantly growing.

In this research, we forecast the pattern of development of wireless data communication (WDC) services and propose effective strategies for service providers by decreasing the uncertainty related to WDC. For that purpose we single out the

main attributes from among the characteristics of WDC technologies and services, and then estimate consumer preferences for each attribute, which enables us to draw some implications in the view point of management and policy.

This paper is organized as follows. Section II describes the two types of WDC services, namely mobile Internet and wireless LAN, and discusses recent trends in the market for them. Section III reviews the conjoint analysis design and its empirical application. Section IV presents and analyzes the estimation results. Finally, section V draws conclusions and implications.

II. Wireless Data Communications

In this section, we describe the main WDC technologies, the types and present status of the communications services sector, and the economic factors influencing competition therein.

1. Types of Wireless Data Communications

There are several representative WDC technologies, including mobile Internet, which uses mobile communication networks; wireless LAN, which offers last-mile services in the last step of ADSL service; Bluetooth, which is designed for very short range wireless data exchange; high-speed mobile Internet (HMI)[1)]; broadband wireless local loop (B-WILL); trunked radio system (TRS); and the telephaser types of WDC.

Among the various WDC technologies, service providers regard mobile Internet and wireless LAN as the major technologies, considering their market-demand prospects, the size of the related devices industry, spillovers to other industries, and data transmission efficiency. We define *mobile Internet* in this paper solely as the process of data transfer using mobile communication networks. In particular, mobile Internet includes data transmission and reception services, e-mail, short message service, multimedia messaging service, and the like.

The mobile communications network, which provides the base for mobile Internet services, has both a 'wide' customer base and a great number of related industries. In the age of early analog technology, service providers offered only voice calls; they began to offer basic data communications services such as e-mail and short message service with the introduction of the second-generation (2G) network. Since 2002, service providers have offered 2.5 generation (2.5G) services actively in the form of general packet radio service and CDMA2000 1x. Recently, they launched the commercial third-generation (3G) services, introducing a packet system and improved transmission speed, in the form of 1xEV-DO (evolution, data-optimized) and W-CDMA systems in some regions, and they are now providing color multimedia WDC services.

Meanwhile, wireless LAN transmits and receives data using a network interface card or LAN card by setting up access points (APs) for ADSL. The standardization of wireless LAN is progressing rapidly, making the wireless LAN market blossom. The 802.11b standard leads the market in the 2.4 GHz industrial, scientific, medical frequency (ISM) band; and competition between 802.11a and high-performance radio local area network type 2 (HiperLAN2) is predicted to unfold in the 5 GHz ISM band.

2. Market Trends

Customers of mobile communications services can be described as a group of consumers constituting the basis of demand for mobile Internet, because mobile Internet services are provided by mobile communication networks and mobile phones. By the end of 2002, the number of people subscribing to mobile phone services had reached 1.136 billion, and 494 million of those used mobile Internet services.

Mobile Internet services were introduced in South Korea in 1998. A total of 30,678,000 people had subscribed to these services by 2003 [1]. According to a survey on mobile Internet [2], by the end of 2004 the diffusion rate had reached 72.1% of the total number of cellular phone subscribers. However, only 34.5% of subscribers to mobile Internet services actually use these services once per month. The revenue of mobile Internet services of SKT, a leading company of the Korean mobile communications market, was just 15.5% of the total revenue of mobile communications services in 2003 [3].

Meanwhile, commercial, public wireless LANs began offering services in South Korea in September 2001. By 2003, 368,000 customers used the services, a rather small number in comparison with the number of mobile Internet subscribers [4]. Korea Telecom, the major provider, leads the market with an 86% market share. An additional three service providers have entered the market. Korea Telecom had constructed 8,000 hotspots by the end of 2002 and plans to set up 930,000 additional APs, investing 301 billion won (US$253 million)[2)].

Table 1. Past and projected subscribers to public wireless LAN services in South Korea, 2002–2007.

Year	2002	2003	2004	2005	2006	2007	Compound annual growth rate
No. of customers (thousands)	100	322	631	993	1,358	1,572	58.3%

1) A recent WDC technology developed in South Korea by the Electronics and Telecommunications Research Institute

2) US$1 = 1,190 won, as of December 2002

In general, an increase of 58.3% in the number of subscribers per year is predicted, and 1.57 million customers are expected to use the services in 2007 [5] as shown in Table 1.

3. Competitive Factors in WDC

Competition between mobile Internet and wireless LAN services arises because of their mutually exclusive and differing characteristics. Those characteristics will play an important role in determining the pattern of development of WDC services; they affect the choices consumers make and alter business prospects. For that reason, we explore the competitive factors of each type of service in this section.

First, the two service types display a difference in regard to terminal device. Usually, mobile Internet is offered through a mobile phone, and wireless LAN service is based on a notebook PC. A personal digital assistant, or PDA, can be used with both service types. The type of terminal device itself suggests the degree of mobility enjoyed by the consumer and the type and variety of WDC services a consumer can receive.

Mobility is an advantage that derives from handoff technology that allows for the seamless transmission of data irrespective of the client's geographic location within a certain coverage area and due to an extensive coverage network. The mobile communications network consists of many hexagonal cells, in the center of which lies a base station. The network uses a handoff function, which makes a continuous connection possible by transferring information about the user to the next base station when the user moves between different cells. Since the network covers the whole nation, the user is practically unrestricted by geographic constraints. To the contrary, a wireless LAN does not use the handoff function, so the user can access the LAN services only in a limited number of places where an AP is set up as a hotspot[3]. Wireless LAN is also called *fixed wireless* for that reason. In addition, users cannot access the LAN services even while at a hotspot if they are moving rapidly.

A variety of content is another factor affecting competition among WDC services. A user can use all kinds of content on the Internet if he uses a large display, because wireless LAN services are complementary to ADSL services. On the contrary, the user of mobile Internet who is using a handset faces several restrictions such as a small display and inconvenient input apparatus.

A third competitive factor is data transmission speed. In wireless LAN, the maximum speed using 802.11b, the major standard, is 11 megabits per second (Mbps) within the 2.4 GHz band, and that using 802.11g is more than 20 Mbps. The maximum speed with the 802.11a standard, which will be operated within the 5 GHz band in the future, reaches 54 Mbps. On the other hand, the maximum speed of mobile Internet is only 2.4 Mbps even in the case of the latest technology, such as CDMA2000 1xEV-DO; the expected maximum speed using 1xEV-DO, the technology of the future, is at most 2.4 to 5.2 Mbps.

Quality of communication is a fourth competitive factor. The providers of mobile Internet use exclusive frequency bands that the government assigns to them. On the other hand, wireless LAN services use the ISM band at no charge, and therefore it is likely that a deterioration of quality—such as through jamming, noise, and breaks—is likely to occur due to radio interference between the equipment of wireless LAN or other equipment.

Another factor affecting competition is price. Nowadays, in South Korea the pricing scheme used for wireless LAN is a monthly flat-sum system, and that used for mobile Internet is usually a meter-rate system. In South Korea, existing ADSL users can make use of wireless LAN services by making an additional fixed monthly payment of 16,000 to 20,000 won (US$13.59 to 16.99)[4], and those not already using ADSL can use these services by paying an additional 25,000 won per month. On the other hand, mobile Internet adopts a circuit pricing scheme based on the amount of time used, and a packet pricing scheme based on the amount of data used. The charge is 16 to 17 won (US$0.0136 to 0.0144) per 10 seconds in the circuit pricing system, or 1.3 to 6.5 (US$0.0011 to 0.0055) won per packet under the packet pricing system depending on the type of data, making mobile Internet access more expensive than wireless LAN service if a consumer is a heavy user[5]. We expect heavy users to gain more utility from the monthly flat-sum system compared with the meter-rate system because they obtain additional utility from unlimited use without any extra payment. Meanwhile, users who use the service for a short time would prefer the meter-rate system.

4. Results of Previous Research

The authors conducted a previous study of WDC services about two years ago [6]. The attributes used in that study are mobility, variety of content, transmission speed, pricing scheme, price, and communication policy. The survey was carried out from August to September 2002. The tobit model[6]

3) Hotspot refers to the region where the service provider has set up an AP. Hotspots are typically crowded places such as fast-food restaurants, cafes, railway stations, universities, and so on.

4) US$1 = 1,177 won, as of August 2003; This exchange rate is used because the questionnaire in this research was conducted in August 2003. The same exchange rate is applied to the conversion of won to US dollar in the following.

5) Packet size differs from nation to nation and depends on the network's transmission speed. In South Korea, one packet is set to equal 512 kilobytes.

6) Tobit model is a representative method to analyze rating data. In the previous research, the respondents rated the alternatives. Generally, rating data contain more information. However, the utility is originally an ordinal concept and using ranking data is desirable for this analysis. Thus, this research uses the ranking data.

using rating data as a dependent variable, and the ordered probit model using ranking data, were used in the analysis. The results of these two models were almost the same.

Under the tobit model, mobility was found to have the largest relative importance (31.93%), and the relative importance of the other attributes was as follows: communication quality (26.17%), variety of content (14.83%), price (14.18%), transmission speed (7.91%), and pricing scheme (4.98 %). The order under marginal willingness to pay (MWTP) was the same as that under relative importance except that MWTP for price is included in the order.

III. Conjoint Design and Empirical Model

In the present study, we analyze patterns of WDC service development and changes in market structure due to the strength in the market of the service providers. Using this analysis, we suggest effective market strategies and estimate their potential impact on the national economy. For this purpose, we estimate the value of the competitive factors of WDC services, and we use data regarding WDC services in South Korea, where the rate of growth for both wireless LAN and mobile Internet services has been exceptionally high.

The market for WDC services reveals characteristics such as rapid development of content and intense competition. Using the revealed-preference approach allows us to obtain only the information on the most-preferred products. In addition, that approach hardly enables us to extract any information on the part-worth of important quality attributes of those products due to insufficient purchasing data in the market. Accordingly, we concluded that the stated-preference approach would be more relevant for meeting our objectives. The methodology we have used is based on stated-preference data collected in a hypothetical choice environment situation. This methodology is commonly known as a conjoint analysis [7]. Thus far, a conjoint analysis has been applied in various fields, such as communications [6], [8]-[10]; transportation [11], [12]; the environment [13], [14]; and medical care [15]. Two of the main applications of this analysis are the pricing of new products [16], [17] and the forecasting of market share.

In this study, we select a few competitive factors pertaining to wireless LAN and mobile Internet services and analyze consumer preferences using a sample of 500 respondents.

1. Conjoint Design

The sample was drawn on the basis of the distribution of mobile communications service subscribers by gender, age, and residential region. Table 2 presents a summary of the sample design. Well educated questioners themselves visited and interviewed 500 respondents. We received the data from all respondents. Then, we excluded the respondents whose answers were irrational or not complete. Finally, the data of 457 respondents were used in the estimation.

Table 2. Sample Design.

	Details
Population	Age 20 to 59, living in Seoul
Sample size	500
Survey period	1 month (August 2003)
Method used in drawing the sample	Allocation by residential region and age
Method used in collecting data	Individual interview using a systematic questionnaire

As shown in Table 3, the attribute cards contain five attributes: terminal device, transmission speed, communication quality, pricing scheme, and price, all of which are factors in the competitiveness of WDC services.

Table 3. Quality attributes and their levels represented on attribute cards.

Attribute	Level
Terminal device	Mobile phone, PDA, notebook PC
Transmission speed	2, 6, 10 Mbps
Communication quality (connection failures or breaks out of 10 trials)	0, 1, 2
Pricing scheme	Monthly flat-sum system Meter-rate system
Monthly rate	30,000 won (US$25.5), 80,000 won (US$68.0), 130,000 won (US$110.5)

First, *terminal device* refers to the device used as a communications terminal: mobile phone, PDA, or notebook PC. The attribute includes the concepts of mobility and content variety as well as the utility of the device itself. Consumers who use mobile Internet with a mobile phone can enjoy the service on the move, wherever they are. On the contrary, consumers using wireless LAN with a notebook PC can use the service only in a restricted area and at a fixed access point. However, wireless LAN service users have the advantage of being able to enjoy the same variety of content as is available on an existing wired Internet service such as ADSL. Mobile Internet users, meanwhile, can use only content that consists of simple graphics and text. A PDA can be used for both types of WDC services. Therefore, a mobile phone means high mobility and limited contents, and a notebook PC represents low mobility and various contents. Finally, a PDA implies high

mobility and various contents. The questioners explained such details to respondents sufficiently before this survey.

Three levels of *data transmission speed* were established: 2 Mbps (the speed level of IMT-2000), 6 Mbps (the median speed of the minimum and maximum levels), and 10 Mbps (the speed of existing wireless LAN). To aid in the respondents' understanding, we provided them with information on the time at each speed level: 43 minutes, 14 minutes, and 9 minutes, respectively, to download a movie clip (650 megabytes), the same memory size as a CD-ROM.

Communication quality is represented as how many times a connection failure or break happens in ten trials. Considering that connection success rates of existing WDC services usually exceed 90%, and are 80% at the least, the levels are set up as zero, once, and twice out of 10 trials.

We categorized the *pricing system* into a meter-rate system and a monthly flat-sum system. The meter-rate system refers to the pricing scheme based on the amount of time used or the volume of data transferred, which is the case for mobile Internet. The monthly flat-sum system refers to the pricing system whereby a fixed fee is charged regardless of the amount of time used or the volume of data transferred, which is the case for wireless LAN or ADSL.

The *price* levels are 30,000, 80,000, and 130,000 won (US$25.49, 67.97, and 110.45) per month, and they include the cost of renting a terminal device as well as an Internet service use charge. Meanwhile, we exclude the base rate, entrance fee, and an additional fee for the special contents because their exact estimation is rather difficult. The levels are set up properly considering present Internet use charges, the prices of terminal devices, and the market interest rate. In the case of the meter-rate system, the price is defined as the usual means charge per one month. Such information was explained to the respondents in detail.

After the selection of these attributes and levels, we made alternative cards. Using selected attributes and levels, a total of 216 cards could be set. We executed an orthogonal test and then compiled twelve cards. When the twelve cards were presented at the same time, ranking them was difficult. So the twelve cards were divided into three groups and each group contained four cards. We then asked the respondents to rank the four cards three times according to their preferences.

2. Empirical Model

We define the indirect utility function of respondents as follows, using the random utility model:

$$U_{ij} = V(w_i, x_j) + \varepsilon_{ij} = V_{ij} + \varepsilon_{ij}, \quad (1)$$

where vector U_{ij} is the utility on alternative j given by respondent i, V_{ij} is a deterministic term and ε_{ij} is a stochastic term of the random utility model, x_j consists of the attribute variables of alternative j, and w_i is the demographic variables of the respondent i.

We used the Bayesian mixed rank-ordered logit model to estimate the value of the attributes. Before the explanation of the Bayesian mixed approach, we present the basic rank-ordered logit (ROL).

When a respondent ranked the J alternatives as $r = (r_1, r_2, \ldots, r_J)$, (2) shows the probability for the rank order [18], [19].

$$\Pr[U(r_1) > \ldots > U(r_J)] = \prod_{h=1}^{J-1} \frac{e^{V_h}}{\sum_{m=h}^{J} e^{V_m}} \quad (2)$$

$$\text{In } L(\beta) = \sum_{i=1}^{N} \text{In} \left(\prod_{h=1}^{J-1} \frac{e^{V_h}}{\sum_{m=h}^{J} e^{V_m}} \right), \quad (3)$$

where β is a parameter vector corresponding to attributes and demographic variables.

Although the ROL model has an advantage in that ranking probability has a simple closed form, it imposes a restriction as an 'independence of irrelevant alternatives (IIA)' that makes the ratio of probabilities between two alternatives fixed as the attributes of other alternatives change and the coefficients for each attribute are the same across consumers. The mixed rank-ordered logit model [9], [20], [21] can capture preference variation by introducing stochastic terms into the coefficients caused by deviations from mean values and allowing these terms to be correlated across each other. With this method, the stochastic component of utility is correlated across alternatives through the model's attributes—that is, the model does not have IIA restriction and is more flexible than ROL. This model can show more rational results by the exclusion of unrealistic restrictions as IIA and the same coefficients across all individuals.

There are two methods to estimate a mixed rank-ordered logit model. One is the traditional method based on the simulated maximum likelihood, the other is the Bayesian method[7]. The Bayesian method has some advantages over the traditional method. First, the problems about convergence such as the sign of the second-order derivative and local maximization, not global, don't happen because the Bayesian method doesn't have an optimization procedure like maximum likelihood estimation. Second, the simulation algorithm of the Bayesian method is less complex, and therefore the simulation

7) The estimation method is based on Bayes's theorem as 'posterior density $\propto$ (likelihood $\times$ prior beliefs)'. In other words, the posterior distribution is decided by the prior beliefs and the current information. Then, the posterior at this time is used as the prior in the next iteration.

speed on computers is generally faster than the traditional method. Considering these advantages, we adopted the mixed rank-ordered logit model with the Bayesian method.[8)]

The model assumes that the parameters have probability distribution. When β_i is assumed to be distributed normally across the population with mean vector b and variance-covariance matrix W (unbounded normal distribution),

$$\beta_i \sim N(b,W) \tag{4}$$

$$\Pr[U(r_1) > \ldots > U(r_J)|\beta] = \prod_{h=1}^{J-1} \frac{e^{V_h}}{\sum_{m=h}^{J} e^{V_m}} \tag{5}$$

$$L(r|b,W) = \int L(r|\beta)\phi(\beta|b,W)d\beta.$$

By the way, normal distribution is inappropriate for the coefficient of a desirable or undesirable attribute that is valued by all customers. Accordingly, we assume that the coefficients of some attributes such as transmission speed, communication quality, and price have log-normal distribution.

From the estimated coefficients of these, we can estimate the marginal willingness to pay for each attribute and simulate the market shares for hypothetical scenarios. The marginal willingness to pay for attribute k is

$$MWTP_k = -\frac{\partial U / \partial k}{\partial U / \partial p}. \tag{6}$$

The probability of respondent i choosing alternative j is

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{ik}}}. \tag{7}$$

The total market share is calculated averaging individual choice probabilities.

IV. Estimation Results

The model's variables are described in Table 4. Although there are many individual-specific variables such as age, sex, region, income, and dummy variables that distinguish between users, we choose only the 'Income beyond 4 million won' dummy variable (*INCOME*) as the individual-specific variable based on the estimated significance levels in our empirical work.

Equation (1) was estimated using the following empirical specification:

$$\begin{aligned} y_{ij} &= \beta_{PDA} PDA_j + \beta_{NPC} NPC_j \\ &+ \beta_{SPEED} SPEED_j + \beta_{QUALITY} QUALITY_j \\ &+ \beta_{PRICESYS} PRICESYS_j + \beta_{PRICE} PRICE_j \\ &+ \beta_{PDA\_INC} PDA\_INC_{ij} \\ &+ \beta_{NPC\_INC} NPC\_INC_{ij} \\ &+ \beta_{SPD\_INC} SPEED\_INC_{ij} \\ &+ \beta_{QUA\_INC} QUALITY\_INC_{ij} \\ &+ \beta_{PSYS\_INC} PRISYS\_INC_{ij} \\ &+ \beta_{PRI\_INC} PRICE\_INC_{ij} + \varepsilon_{ij} \end{aligned} \tag{8}$$

Table 4. Variables in the model.

Variable	Description	Level
Dependent variable		
RANK	Rankings given by the respondents	1–4 (1 = best; 4 = worst)
Independent variables		
PDA[a)]	PDA	1 if it is PDA 0 otherwise
NPC[a)]	Notebook PC	1 if it is notebook PC 0 otherwise
SPEED	Transmission speed (Mbps)	2, 6, 10
QUALITY	Connection failures or breaks out of 10 trials	0, 1, 2
PRICESYS	Pricing scheme	1 if it is monthly flat-sum system 0 if it is meter-rate system
PRICE	Monthly rate	30,000 won (US$25.5), 80,000 won (US$68.0), 130,000 won (US$110.5)
Interaction terms with income beyond 4 million won		
PDA_INC	Interaction between PDA and income dummy variable	*PDA*×*INCOME*[b)]
NPC_INC	Interaction between NPC and income dummy variable	*NPC*×*INCOME*[b)]
SPD_INC	Interaction between SPEED and income dummy variable	*SPEED*×*INCOME*[b)]
QUA_INC	Interaction between QUALITY and income dummy variable	*QUALITY*×*INCOME*[b)]
PSYS_INC	Interaction between PRICESYS and income dummy variable	*PRICESYS*×*INCOME*[b)]
PRI_INC	Interaction between PRICE and income dummy variable	*PRICE*×*INCOME*[b)]

a) Both *PDA* and *NPC* are zero if the terminal device is a mobile phone.
b) *INCOME* is 1 when the monthly income of a respondent is more than or equal to 4 million won (US $3398.47); otherwise 0.

Table 5 shows the estimation results. The mean b and variance W of β are estimated, and standard errors are drawn respectively by Bayesian simulation. Equation (8) is used in the model, and the probability distribution of coefficients is

8) See the details ([9], [20])

Table 5. The estimation result of Bayesian mixed rank-ordered logit model.

	Mean	Variance	MWTP (monthly rate)
PDA (N)	0.463*	0.566*	5,130 won (US$4.36)
NPC (N)	0.222*	0.604*	1,630 won (US$1.38)
SPEED (L)	0.3820*	0.2374*	4,780 won (US$4.06)
QUALITY (L)	-0.0206*	0.0012*	1,250 won (US$1.06)
PRICESYS (N)	-0.3079*	0.6603*	–2,330 won (–US$1.98)
PRICE (L)	-1.2639*	50.7034*	
PDA_INC (N)	0.3041*	0.5392*	
NPC_INC (N)	-0.0661	0.8613*	
SPD_INC (N)	0.3883*	0.2553*	
QUA_INC (N)	0.3612*	0.6858*	
PSYS_INC (N)	0.0729	1.0585*	
PRI_INC (N)	0.1910*	0.3228*	

N: Normal distribution.
L: Log-normal distribution.
* H_0: β =0 is rejected at the significance level of 5%.

induced additionally in the Bayesian mixed rank-ordered logit model.

The coefficients of attributes such as terminal device, pricing scheme, and interaction terms with income can be positive or negative; thus we assume the coefficients have a normal distribution. In the cases of a desirable attribute such as speed, or undesirable attributes such as quality and price, they are transformed into a log-normal distribution.

MWTP represents the amount of money consumers will pay for a one-unit change in an attribute. To estimate the MWTP amounts in Table 5, we calculated the mean value of the MWTPs of all respondents. For the continuous variables *SPEED* and *QUALITY*, the MWTP means the WTP for a 1 Mbps improvement and for a one-unit improvement in connection failures or breaks, respectively.

According to the estimation results, both terminal device coefficients have significantly positive values, meaning the PDA and notebook PC are preferred more than the mobile phone. In addition, the coefficient for a PDA is larger than that for a notebook PC, indicating that the order of preference is PDA, notebook PC, and mobile phone. The terminal device attribute is not a measure of only the function as a communications device itself, but also of mobility and variety of content. Mobile Internet accessed via a mobile phone or PDA has the advantage of mobility, and wireless LAN accessed with a notebook PC or PDA has the advantage of a variety of content. Discussing the estimation results, consumers seem to prefer wireless LAN because they think a variety of content is more important than mobility. This differs considerably from the finding of the previous research [6], where the relative importance of mobility was more than twice that of content variety. Moreover, in the current study, consumers evince a strong preference for a PDA, which is compatible with both types of WDC service.

The coefficients for connection speed have a significantly positive sign. The MWTP amount for a 1 Mbps improvement is 4,778 won (US$4.06)/month under the model. When the speed increases from 2 Mbps (minimum level in the cards) to 10 Mbps (maximum level in the cards), the WTP amount for the improvement is 38,224 won (US$32.48)/month. This is a relatively large amount of money, which implies that wireless LAN has a competitive advantage in this respect compared with mobile Internet.

The MWTP amount for a one-unit decrease in connection failures or breaks out of 10 trials is 1,247 won (US$1.06)/month. This small amount indicates that this attribute is not a very important factor affecting competition between WDC services. This result is also contrary to the previous research finding [6], where the quality attribute is the second-most important attribute following mobility. This seems to be because consumers have become less sensitive due to the general improvement in communication quality across WDC services. Moreover, in the previous research, the levels of communication quality were set only as 'good' or 'bad,' which is somewhat obscure, and an attribute such as transmission speed was not well separated from the quality attribute. However, in the present study, we can separate preferences regarding communication quality from those regarding other factors through a concrete definition of the quality attribute.

We categorize the pricing scheme into a monthly flat-sum system and a meter-rate system, and the coefficient of the pricing scheme dummy variable presents the utility of the monthly flat-sum system in comparison with that of the meter-rate system. The coefficients for the pricing scheme have a negative sign. In other words, consumers prefer the meter-rate system according to the results. Under the estimation model, a consumer is willing to pay 2,332 won (US$1.98)/month for the change from a monthly flat-sum system to a meter-rate system, and this also is contrary to the previous research results [6]; that study found that consumers preferred a monthly flat-sum system to the meter-rate system. The monthly flat-sum system has the advantage of unlimited use with no extra payment but comes with the disadvantage that a consumer must pay the regular cost even if he seldom uses the service. At the time of the previous survey, consumers expected to use the service for a long time, and they showed a preference for the monthly flat-sum system without additional payment. However, when

WDC services become widespread, consumers may prefer the meter-rate system[9] because consumers have found they do not use the service as much as they had expected they would. However, WTP from a monthly flat-sum system to a meter-rate system is relatively small. And if consumers use the services more in the future, the pattern of consumer preference will change.

We choose income as the demographic variable in the interaction terms. Several variables such as age, sex, and income are tested, and the model, which includes the interaction terms with income, shows the most significant coefficients. The coefficients of the interaction terms—income with PDA, transmission speed, quality, and price—are significant, and all of them have a positive sign. The positive coefficient of the interaction term 'income with PDA' implies that the larger a consumer's income is the more preference he will have for a PDA. In other words, the higher a consumer's income, the larger preference he has for the device, which has advantages in both mobility and variety of contents. The positive coefficient of the interaction term 'income with transmission speed' means that the larger a consumer's income, the more sensitive he is to transmission speed. Finally, the positive coefficients of the interaction terms 'income with quality' and 'income with price' implies that the larger the consumer's income, the less sensitive he is to quality and price, and less sensitivity to price is in accordance with common sense.

Table 6 summarizes the relative importance of each attribute that can be derived using the estimated parameters. *Relative importance* in this case is defined as a share of part-worth of each individual attribute in the sum of part-worth of all attributes. Price has the highest relative importance, and the sum of the part-worth of price and transmission speed together exceeds 90%. This is notably different from what was found in the previous study [6]; in that study, the relative importance of transmission speed was only 8%, and that of communication quality was 26%, which is relatively large. Comparing the current findings to the previous ones, the relative importance of the quality attribute has decreased remarkably and that of the speed attribute has increased considerably. This seems to be caused by changing consumer preference as time goes by or by the consumer's clear recognition given the concrete definition of the quality attribute. The relative importance assigned to the terminal device is less than expected; however, that does not mean the terminal device attribute is not important in WDC service. It seems to result from the offset between the various factors included in the terminal device, such as mobility and variety of content.

Table 6. Relative importance.

Attribute	Percentage (%)
Terminal device	3.40
Transmission speed	25.13
Communication quality	1.79
Pricing scheme	1.59
Price	68.08

Table 7. Simulated market share.

	Mobile Internet	W-LAN
Terminal device	Mobile phone	Notebook PC
Transmission speed	2 Mbps	10 Mbps
Communication quality (connection failures or breaks out of 10 trials)	0	0
Pricing scheme	Monthly flat-sum system	Monthly flat-sum system
Monthly rate	45,000 won ($38.23)	90,000 won ($ 76.47)
Market share	34.09 %	65.91 %

The relative importance of price has increased drastically in comparison with the previous study's results [6]. Consumers seem to be more sensitive to price now because the price is presented on the attribute cards as a monthly price, which is a more recognizable and realistic representation than price per 10 seconds of use, the representation used in the previous survey.

Finally, using the estimated coefficients, we simulate the market share. Table 7 presents the simulation results.

The attributes of mobile and wireless Internet are set as shown in Table 7. The levels of terminal device, speed, and price are different, and those of quality and pricing scheme are the same.[10] Prices, including the rental cost of a terminal device, are set as 45,000 ($38.23)[11] and 90,000 ($76.47)[12] won for mobile and wireless Internet, respectively. The market share of wireless LAN is almost twice as that of mobile Internet. Because the WDC market is still at an early stage, a comparison between the simulated results and actual data is

9) Relatively low priced to consumers who use the service for a short time

10) The levels of quality are same as '0' in both services. At the present time, the success rates of WDC connection are almost 100% in both services due to the technological development. So, we set the both levels as '0'. And we set the levels of pricing scheme as "monthly flat-sum system" in both services because the price attribute is presented as the monthly cost.

11) We assume that the monthly cost of mobile internet is 25,000 won ($21.24), the usual present monthly cost of mobile communication service, and the monthly rental cost of a mobile phone is 20,000 won ($16.99) based on 2 years usage of about 500,000 won ($424.81).

12) We assume that the monthly cost of wireless LAN is 16,000 won ($13.59), the usual present monthly cost of wireless LAN (meaning only the additional cost for wireless LAN except wired internet service cost) , and monthly rental cost of a notebook PC is 74,000 won ($62.87) based on 2 years usage of about 1,700,000 million won ($ 1444.35).

Table 8. Simulated market share (including Wibro).

	Mobile Internet	W-LAN	Wibro
Terminal device	Mobile phone	Notebook PC	PDA
Transmission speed	2 Mbps	10 Mbps	8 Mbps
Communication quality (connection failures or breaks out of 10 trials)	0	0	0
Pricing scheme	Monthly flat-sum system	Monthly flat-sum system	Monthly flat-sum system
Monthly rate	45,000 won ($38.23)	90,000 won ($76.47)	60,000 won ($50.98)
Market share	16.89%	37.81%	45.29%

impossible. However, the results show the competitive power of wireless LAN in the WDC market.

Tabe 8 shows the simulation results when Wibro[13] appears in the WDC market as an alternative technology.

A PDA is assigned for the level of terminal device in Wibro. Although other devices such as a mobile phone and Notebook PC can be used in Wibro, we choose a PDA because it indicates high mobility and various contents, which are intrinsic characteristics of Wibro. The speed is set as 8 Mbps, near the speed of wireless LAN. We set the price as 60,000 won ($50.98).[14]

According to this result, the effect of Wibro introduction in the WDC market seems to be large, and Wibro has a considerable advantageous position in the WDC competition.

V. Conclusions

Judging by the estimation results, especially those regarding MWTP and the relative importance of transmission speed, wireless LAN service seems to occupy a superior competitive position to mobile Internet in the WDC service market when considering consumer preferences. We attribute this to the consumer's ability to use the services more conveniently given the development of wireless LAN technologies and the extension of the service area. Moreover, an increasing desire for a variety of content contributes to this situation.

Data transmission speed presents a large WTP and relative importance, and such preference for speed is larger in the high income groups. Because wireless LAN has higher upload and download speeds than mobile internet, the results about speed variable also support the competitive power of wireless LAN service. However, because a PDA or notebook PC used in wireless LAN service is more expensive than a mobile phone, we should consider price in order to assert the preference of consumers for wireless LAN.

To gain a superior position in the competition, PC producers should make an effort to enhance the merits of wireless LAN and reduce notebook PC prices. Meanwhile, to survive in the market, mobile phone producers should concentrate their efforts on developing various contents for WDC in consideration of consumer preferences and on improving data transmission speed. As for policymakers, the findings suggest that they establish policy so as to support and develop the service content industry in consideration of increasing consumer desire for a variety of content.

One notable result is the preponderance of preference for the PDA as the terminal device, especially in high income groups, implying that consumers have a marked preference for the convergence of both types of WDC service. The PDA is representative of a dual-mode terminal device that facilitates a kind of convergence, high mobility and various contents such as Wibro. Accordingly, terminal device producers have an incentive to promote an investment in research and development of dual-mode terminal devices. This argues for policymakers to encourage such product innovation. The development of technologies supporting dual-mode terminal devices will be a very important factor in the structuring of the mobile communications industry in the near future.

In this study, the relative importance of price exceeds the sum of the other attributes' relative importance. If consumers are as sensitive to price as this, price reductions will play a more important role in the diffusion of WDC services than other factors such as changes in pricing scheme, improvements in communication quality, and so forth. Service content providers must therefore make an effort to reduce the service use charge through technical developments and efficient management. Moreover, terminal device producers should follow a market strategy of reducing production costs and purchase price through process innovation as well as product innovation in the form of a dual-mode terminal device, given that in this study price reflects the rental cost of terminal devices.

13) Wibro is a wireless technology, portable internet, which can provide broadband services over long distance even when fast moving. Wibro is the technological standard of portable internet in Korea, similar to Wimax in the USA. It has higher mobility than wireless LAN and more various contents than mobile internet. The data transmission speed is several times as mobile internet and near wireless LAN.

14) We assume that the monthly cost of Wibro is 35,000 won ($29.74), usual present monthly cost of mobile communication service, and monthly rental cost of PDA is 25,000 won ($21.24) based on 2 years usage of about 600,000 won ($509.77).

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