Effects of consumer preferences on the convergence of mobile telecommunications devices

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Amidst the overall trend of convergence in information technology, device convergence is noteworthy. This study looks at the possible direction of device convergence based on consumer preferences for the main attributes of the mobile terminal of the future. Conjoint analysis and a mixed logit model using a Bayesian approach with Gibbs sampling are used to learn consumer preferences. Results show that consumers generally prefer a keyboard and a medium-sized display, although at present most consumers are indifferent to whether the terminal provides high-quality Internet service and to whether it operates many kinds of application programs or programs originally designed for personal computers. Given the heterogeneity of consumer preferences, partial, rather than perfect, device convergence is anticipated. Implications for the future of device convergence and how it will affect other types of convergence are drawn.

I. Introduction

Convergence represents an important trend in information technology (IT). Several particular types of convergence are noted. For example, in service convergence various services are incorporated into one converged service. In network convergence separate networks are incorporated into a converged network; this has happened to the extent that the distinction between wired and wireless networks is no longer meaningful. In marketing and business convergence, many value chains or business strategies are changed to a newer and converged chain or strategy. In interface and terminal convergence, also referred to as device convergence, many kinds of extant devices and terminals used for various means are incorporated into a new, converged device that enables consumers to use the converged services and connect to the converged network.

Convergence itself is an important trend not only in IT but also with respect to twenty-first century society as a whole. As time goes by, given the rapid progress in information technologies and changing consumer needs, the trend towards the overlapping and incorporating of application fields, and the blurring of distinctions between previously separate industries, will become ever more prevalent (Blackman, 1998). Convergence will be a new driving force for IT industries suffering from market saturation as it will create new demands, drastically change market structures, require new policies and regulations, inspire firms to set new research-and-development or business strategies, and affect the whole society.
This study focuses on convergence with regard to the mobile telecommunications terminal. Using conjoint analysis, it estimates consumer preferences regarding the future multiuse-converged mobile terminal, and predicts the future direction of device convergence in mobile telecommunications.

The terminal or device convergence one sees in mobile telecommunications has its own importance – first, in terms of the huge influence it will exert on the large-scale, fast-growing device and terminal industries, and second, through a ‘feedback effect’, by which it will affect other convergences such as service convergence and network convergence.

The existing literature on convergence generally has focused on service or network convergence or on the convergence phenomenon as a whole. Authors have seldom treated device convergence as a main topic, and their analysis of the topic has been intuitive rather than based on quantitative data. This study differs in that it analyses device convergence mainly, and the analysis is based on quantitative information about consumer preference.

Consumer preference is the most important factor in determining the direction device convergence will take, because device convergence applies to the terminal or device the consumer uses directly in his or her hands. Moreover, recently a fairly large part of the development of IT products has been dominated by the pull of demand rather than the push of technology. Yoffie (1997) refers to the example of device convergence between the television and the videocassette recorder, noting that although technology may make the device convergence possible, if there is not enough consumer demand, that device convergence will fail in the end.

To estimate consumer preference, conjoint analysis is used. Conjoint analysis is a method used to analyse consumer preference for a new product that has not appeared in the market. Some important attributes concerned with future mobile terminal convergence are chosen and hypothetical alternatives composed with them. Those alternatives are shown to respondents and ranked.

This procedure yields information about consumer preferences for the main attributes of the multiuse-converged mobile terminal of the future, and it allows one to identify attributes that figure critically in device convergence. In addition, some implications of device convergence are found for other convergences, such as service convergence and network convergence.

For statistical models, mixed logit using the Bayesian approach with Gibbs sampling is estimated (Allenby and Rossi, 1999; Chiang et al., 1999; Huber and Train, 2001; Train, 2003). The mixed logit model has the advantage of not imposing restrictions on the ordering of preferences so that coefficients for each attribute are the same across consumers as with a multinomial logit model (Layton, 2000; Calfee et al., 2001). Accordingly, it provides a flexible means for representing the distribution of preferences on each attribute change in the population.

The remainder of the paper is organized as follows: Section II: introduction to issues affecting mobile telecommunications device convergence; Section III: methodology and survey details; Section IV: estimation results; Section V: implications; Section VI: concluding remarks.

II. Issues Affecting Mobile Telecommunications Device Convergence

The first step in an analysis of mobile telecommunications device convergence is the identification of the general factors that shape such convergence. Roughly, such issues can be categorized into three: one, the extent to which device convergence is likely to occur; two, the specific attributes of the device; and three, the effect of device convergence on other types of convergence.

Extent of device convergence

Regarding this question there are at least two schools of thought. One is that technological progress and the needs of consumers for converged services and many functions will bring all kinds of terminals and devices together, and in the end they will be incorporated into one device. According to this way of thinking, almost complete device convergence is likely. The second school holds that although service and network

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1 Blackman (1998) dealt with the convergence phenomenon as a whole, treating convergence between telecommunications and media, and showing some implications for new, appropriate regulatory frameworks. Messerschmitt (1996) dealt with convergence between computing and telecommunications technologies, specifically in terms of networked computing applications, and emphasized the importance of user-to-user applications in convergence. Mueller (1999) also dealt with convergence as a whole. In his working paper, in regard to device convergence, he insisted that because of the new media ecology and technological improvements, devices and applications would become more diverse and specialized while becoming more interoperable. Yoffie (1997) referred to past examples of device convergence such as between the television and the videocassette recorder and emphasized knowing whether consumer needs exist or not to predict success of device convergence.
convergence will become more and more likely, because of the diversity of consumer demands and tastes the device will evolve into many types. Mueller (1999) posits that rather than a perfect level of device convergence being achieved, it is more probable that current terminals and devices will evolve into some application-specific devices that can be used regardless of the service or network they are connecting to. That is to say, partial device convergence is the most likely outcome.

Naturally it cannot be said for sure which theory will prevail. But is there not a method by which one might predict which outcome is the more likely? To find that method, one should, above all, identify the factors that will affect the extent of device convergence. The two theories presented above share the idea that consumer needs and preferences will be key factors in device convergence. Therefore, knowing the extent of the heterogeneity of consumers’ preferences can help tell one which outcome is more probable. In this study, the mixed logit model is adopted, which can reflect the heterogeneity of consumers’ preferences well.

Specific attributes of the future mobile device

Regarding attributes, there are many issues. But this study focuses on the following attributes because, for example, even though colour or design may be important factors that attract consumers to a device, it is thought that they are not very significant factors bearing on device convergence and therefore are not of profound importance here:

- How large should the display be, and how portable should the future mobile device be?
- What kind of input equipment will most likely be adopted?
- What level of Internet service quality should the future mobile device provide?
- Is it desirable for a future multiuse mobile terminal to provide very diverse application programs, or is it desirable that the terminal be compatible with a personal computer (PC)?

The preceding issues can be separated into two categories: issues directly related to device convergence and issues not directly related to the device convergence phenomenon, but having significance. The second and the fourth questions above are directly related to device convergence. The third question is not directly related to device convergence itself; however, it may affect the future direction of device convergence very much, and it also holds important meaning for service convergences in mobile telecommunications. The first question is not directly related to the device convergence phenomenon, either. However, it has bearing on device convergence because portability and display size are key factors when determining the form factor of the future multiuse-converged mobile terminal, and the form factor comes into play when consumers choose devices.

Effect of device convergence on other types of convergence

How do the changing preferences of consumers for devices affect convergence in services and networks? This feedback effect is another issue that is considered.

III. Methodology

Because this study focuses on mobile device convergences that are not yet on the market, conjoint analysis is used for demand analysis. Conjoint analysis is a stated-preference technique that has been widely applied in marketing (Huber and Train, 2001); transportation research (Carlsson, 2003); health economics (Bryan and Parry, 2002; San Miguel et al., 2000); and environmental economics (Roe et al., 1996; Layton, 2000); among others. Using the conjoint technique, levels of attributes or features describing a good, service, or policy are combined to build descriptions of hypothetical bundles. Individuals are asked to state their preferences for hypothetical alternatives, and their responses are then analysed using statistical models (Alvarez-Farizo and Hanley, 2002).

The survey used in this study asks respondents to rank order a set of alternatives. The reason for using contingent-ranking results is that the method can reduce sampling costs substantially because more information is recovered from each respondent than can be gotten when respondents provide only a single response, that of their most preferred choice (as in a referendum) (Layton, 2000).

In contingent-ranking conjoint analysis, a rank-ordered logit model (Layton, 2000; Calfee et al., 2001) is generally used for estimation. Although this model has an advantage in that ranking (choice) probability has a simple closed form, it imposes restrictions on the ordering of preferences in such a manner that coefficients for each attribute are the same across consumers.

The mixed logit model captures preference variation by introducing stochastic terms into the coefficients caused by deviations from mean preferences 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 impose an ‘independent of irrelevant alternatives’ property (Calfee et al., 2001).

Procedures for estimating the mixed logit model have been developed within both the classical and the Bayesian traditions. The classical methods of estimation are generally based on the maximum likelihood estimation. Applications of the mixed logit model using a classical approach are given in Brownstone and Train (1999), Layton (2000), Calfee et al. (2001), and Carlsson (2003).

Allenby and Rossi (1999), Chiang et al. (1999), Huber and Train (2001), and Train (2003) have developed Bayesian approaches to the mixed logit model. This method constructs a Markov chain Gibbs sampler that can be used to draw directly from the exact posterior distribution and perform finite sample likelihood inference to any degree of accuracy (McColluch and Rossi, 1994).

These Bayesian procedures have certain advantages over the classical procedure. First, one can avoid direct evaluation of the nontrivial likelihood function and the associated problems of approximating choice probabilities that are required with classical methods. In addition, the mathematical properties of the multinomial model do not guarantee convergence of maximum likelihood estimation to a global maximization, and the solution obtained by a nonlinear programming optimizer may depend critically on the location of the starting point.

Second, desirable estimation properties, such as consistency and efficiency, can be attained under more relaxed conditions using Bayesian procedures compared with classical methods. Maximum simulated likelihood is consistent only if the number of draws used in a simulation is considered to rise with sample size; efficiency is attained only if the number of draws rises more quickly than the square root of the sample size. In contrast, Bayesian estimators are consistent for a fixed number of draws used in a simulation and are efficient if the number of draws rises, at any rate, with the sample size (Train, 2003).

Third, the results of Bayesian procedures can be interpreted simultaneously from both the Bayesian and classical perspectives, drawing on the insights afforded by each tradition. The Bernstein von Mises theorem establishes that, under conditions maintained in this study’s methods, the mean of the Bayesian posterior is a classical estimator that is asymptotically equivalent to the maximum likelihood estimator. The theorem also establishes that the covariance of the posterior is the asymptotic covariance of this estimator (Train and Sonnier, 2003).

Model specification

Assume that individual \( i \) faces a choice among \( J \) alternatives in each of \( T \) choice sets in a survey and the individual is asked to rank the alternatives in order of preference. One can represent the person’s utility from alternative \( j \) in choice set \( t \) as follows:

\[
U_{ijt} = \beta_j x_{ijt} + \epsilon_{ijt}
\]

(1)

where \( x_{ijt} \) is the vector of attributes associated with alternative \( j \), \( \beta_j \) is a vector of unknown parameters (the coefficients of attribute vector \( x_{ij} \)), and \( \epsilon_{ijt} \) is a random disturbance.

The random disturbance (\( \epsilon_{ijt} \)) is assumed to have an independent and identical extreme value distribution. The coefficients vector, \( \beta_j \), is assumed to be distributed normally across the population with mean vector \( b \) and variance-covariance matrix \( W \) (unbounded normal distribution).

In this contingent-ranking conjoint analysis, one can adopt the same procedure as in Train (2003) for Bayesian estimation. The only change is that one should calculate the probability of the individual’s sequence of rankings, which is used in the Metropolis-Hasting (M-H) algorithm, instead of the probability based on the response of the most preferred choice as in Train (2003). The probability of person \( i \)’s observed sequence of rankings is

\[
L(r_i = \{r_{i1}, \ldots, r_{iT}\} \mid \beta) = \prod_{t=1}^{T} \prod_{j=1}^{J} \frac{e^{\beta_j x_{ijt}}}{\sum_{k=J}^{J} e^{\beta_k x_{ikt}}}
\]

(2)

where \( r_{it} = \{r_{i1t}, r_{i2t}, \ldots, r_{iJt}\} \) is the vector of individual \( i \)’s ranking responses of the choice sets in descending order of preference in period \( t \).

The unbounded normal distribution for a price coefficient has some inappropriate properties. A normal distribution for a price coefficient implies that some share of the population actually prefers higher prices. The existence of price coefficients with the wrong sign renders the model unusable for calculation of willingness to pay and other welfare measures, and if the distribution of price coefficients overlaps zero, then the willingness to pay is unboundedly large for some customers (Train and Sonnier, 2003). In this application, we assume that the price coefficient has a log-normal distribution.

\(^2\) For details, see Train (2003, pp. 302–6).
This distribution has beneficial properties in that it restricts the price coefficient for all respondents to having the same sign, and the price coefficient cannot have a value of zero. This distribution can be obtained as simple transformations of normal ($\beta$), $C = \exp(\beta)$.

Unbounded normal distribution is also inappropriate for the coefficient of a desirable attribute that is valued (or, at worst, ignored) by all customers. It is implausible that there are users who dislike the higher quality of service, that is, users who choose lower quality of service, even though doing so actually costs the same as choosing the higher-quality service. Accordingly, we assume that the coefficients of attributes such as ‘quality of Internet’ and ‘diversity and compatibility of application programs’ have normal distribution censored from below at zero. The transformation for normal censored from below at zero is $C = \max(0, \beta)$. This transformation is useful for coefficients of an attribute to which some customers are indifferent and other customers find desirable (Train and Sonnier, 2003).

When a transformation is used for bounded distributions of a coefficient, utility is specified as follows:

$$U_{ijt} = C(\beta_i) x_{ijt} + \varepsilon_{ijt}$$

where $C$ is a transformation.

There are minor changes in the estimation procedure with this transformation. The probability of the individual’s sequence of ranking, which is used in the M-H algorithm, should be changed based on transformed $\beta_i$ (Train and Sonnier, 2003).

Survey and data

For this study, respondents were surveyed who have at least one kind of mobile terminal such as a notebook PC, mobile phone, smart phone, personal digital assistant (PDA), satellite phone, and so on. The survey was first conducted among 500 respondents; 55 of those were later discarded because of lack of some information. The survey was restricted to adults ranging in age from 20 to 60 in May 2003, in Seoul, Korea. To improve the reliability of the complex conjoint survey, a one-to-one direct interview method by well-trained interview specialists was used. Critical attributes and levels were selected from a pilot test before the real test. Table 1 shows the attributes and their levels used in the actual survey. They reflect the important issues for device convergence discussed in Section II.

Note that preference for portability was not included as an attribute in the real survey despite its importance to the form factor of the device. Preference for portability can be inferred from preferences for other attributes, and one should avoid double-counting bias. It is assumed that preference for the display size can almost directly reveal preference for portability. Drawings of squares are included in real size corresponding to attribute level settings to make respondents consider portability when they considered their preference for display size.

On the other hand, to characterize preference for portability as mainly associated with the display size, due notice had to be given in the interview process that the size of the keyboard is not overly related to portability. To do so, the interviewer was asked to explain carefully to respondents that the keyboard can be an attachable, foldable or modifiable type that does not affect portability very much.

Because the number of alternative cards was too large, fractional factorial design was used to reduce that number, and 15 alternative cards were finally arrived at. Because respondents tend to evaluate three or four higher-ranking alternatives seriously and evaluate the lower-ranking alternatives trivially, the 15 alternative cards were divided into three sub-alternative card sets consisting of five cards each. Thus, respondents were asked to rank those five cards three times. (For details on the survey cards, see the Appendix.)

Table 1. Attributes and attribute levels

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Attribute levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pricea</td>
<td>400 000 won</td>
</tr>
<tr>
<td></td>
<td>550 000 won</td>
</tr>
<tr>
<td></td>
<td>700 000 won</td>
</tr>
<tr>
<td>Type of input equipment</td>
<td>Keypad (0)</td>
</tr>
<tr>
<td></td>
<td>Keyboard (with trackball mouse)</td>
</tr>
<tr>
<td></td>
<td>Touchscreen</td>
</tr>
<tr>
<td>Quality of Internet</td>
<td>Low-quality Internet: able to embody contents- and letter-based Internet only (e.g., CDMA2000) (0)</td>
</tr>
<tr>
<td></td>
<td>High-quality Internet: able to embody desktop PC-like Internet (e.g., wireless LAN)</td>
</tr>
<tr>
<td>Diversity and compatibility of application programs</td>
<td>Low level: only application programs specially designed for the terminal can be operated (0)</td>
</tr>
<tr>
<td></td>
<td>High level: many application programs can be operated; also, many application programs for PC can be operated compatibly</td>
</tr>
<tr>
<td>Display size</td>
<td>Small display (small mobile phone – large-display mobile phone)</td>
</tr>
<tr>
<td></td>
<td>Medium display (large-display mobile phone – PDA)</td>
</tr>
<tr>
<td></td>
<td>Large display (PDA – compact notebook PC) (0)</td>
</tr>
</tbody>
</table>

aData at the time of the survey (May 2003), 1199.8 Korean won approximately equals 1 US dollar.
**IV. Estimation Results**

Except for price, which is a quantity variable, to estimate the coefficients of dummy variables for the attributes, keypad, low-quality Internet, low-level diversity and compatibility of application programs, and large display were chosen as the base attribute levels. Thus the estimated coefficients signify the relative preferences for these base attribute levels.

It is assumed that the coefficients of high-quality Internet and high-level diversity and compatibility of application programs have censored normal distribution. In addition, log-normal distribution was assumed for the coefficients of price.

This application generated 20,000 draws with Gibbs sampling. The first 10,000 were discarded, and the draws in every tenth iteration of the second 10,000 draws were retained; the 1000 retained draws were used to conduct inference. The means of the 1000 draws of \( b \) and those of the diagonal elements of \( W \) are shown in Table 2.

From the Bayesian perspective, these are posterior means of \( b \) and the diagonal elements of \( W \); from the classical perspective, these represent the estimated mean and variance of the \( \beta_i \) in the population. The research interpreted these results from the classical viewpoint. From the estimation results of Table 2, the means of the coefficients are significant in general, and the variances of all coefficients are large in magnitude and significant as well. This means that a lot of heterogeneity exists in consumers’ preferences for the critical attributes of the future mobile telecommunications terminal. This result justifies the use of the mixed logit model rather than the standard logit model, and it helps one to answer the question ‘To what extent is device convergence likely to happen?’.

Because \( b \) and \( W \) are the mean and the variance of the \( \beta_i \) in the population according to the classical perspective, the distribution of the coefficient for each variable is obtained through simulation on the estimated values of \( b \) and \( W \). Two thousand draws of \( \beta_i \) were taken from a normal distribution with mean equal to the estimated value of \( b \) and variance equal to the value of \( W \). Each draw of \( \beta_i \) was then transformed to obtain a draw of coefficients. Table 3 shows means and variances of these coefficients.

The result shows that variance of price is very large, which means that very different patterns of response to price will be found among consumers. From Table 3, consumers prefer a medium-sized display, a keyboard, high-quality Internet, and a high

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Mean of ( \beta (b) )</th>
<th>Standard deviation of ( \beta (b) )</th>
<th>Variance of ( \beta (W) )</th>
<th>Standard deviation of ( \beta (W) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>-4.7169*</td>
<td>(0.6578)</td>
<td>7.0460*</td>
<td>(2.1857)</td>
</tr>
<tr>
<td>Keyboard</td>
<td>0.4291*</td>
<td>(0.0721)</td>
<td>0.4393*</td>
<td>(0.0939)</td>
</tr>
<tr>
<td>Touchscreen</td>
<td>-0.1627*</td>
<td>(0.0741)</td>
<td>0.4173*</td>
<td>(0.0779)</td>
</tr>
<tr>
<td>High-quality Internet</td>
<td>-0.9597</td>
<td>(0.5026)</td>
<td>2.5462*</td>
<td>(1.1332)</td>
</tr>
<tr>
<td>High-level diversity and compatibility</td>
<td>-1.5821*</td>
<td>(0.5198)</td>
<td>3.8201*</td>
<td>(1.3570)</td>
</tr>
<tr>
<td>Small display</td>
<td>0.0560</td>
<td>(0.0871)</td>
<td>0.7572*</td>
<td>(0.1647)</td>
</tr>
<tr>
<td>Medium display</td>
<td>2.1273*</td>
<td>(0.1177)</td>
<td>1.7267*</td>
<td>(0.3300)</td>
</tr>
</tbody>
</table>

*The price variable is entered as the negative of price so that the distribution of the coefficient (transformed distribution) for price is everywhere positive.

*Significant at the 5% level.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Attribute levels</th>
<th>Mean</th>
<th>Variance</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>Keyboard</td>
<td>0.4192</td>
<td>0.4244</td>
<td>0.4218</td>
</tr>
<tr>
<td>Input equipment</td>
<td>Touchscreen</td>
<td>-0.1421</td>
<td>0.4528</td>
<td>-0.1187</td>
</tr>
<tr>
<td>Quality of Internet</td>
<td>High-quality Internet</td>
<td>0.2653</td>
<td>0.3619</td>
<td>0.0000</td>
</tr>
<tr>
<td>Diversity and compatibility of application programs</td>
<td>High-level diversity and compatibility</td>
<td>0.2360</td>
<td>0.4053</td>
<td>0.0000</td>
</tr>
<tr>
<td>Display size</td>
<td>Small display</td>
<td>0.0699</td>
<td>0.7037</td>
<td>0.0778</td>
</tr>
<tr>
<td></td>
<td>Medium display</td>
<td>2.0731</td>
<td>1.6988</td>
<td>2.0520</td>
</tr>
</tbody>
</table>
level of diversity and compatibility of application programs on average.

To analyse the distributions of coefficients further, the share of respondents who prefer some attribute levels or who are indifferent was estimated, as shown in Table 4.

Diversity and compatibility of application programs, used as an index for the performance of the terminal, are not valued much by most consumers (79.25%). This means that for most people, the future mobile telecommunications terminal need not have high-level performance and specifications if those cost more.

High-quality Internet is not valued much by many consumers (71.6%) either. This means that when Internet service is to be used on the mobile terminal, consumers are not willing to pay more for high-quality Internet service rather than low-quality Internet service.

Surprisingly, these last two results run counter to the general intuition that such characteristics are ones that should attract consumers very much and that should be included in any future mobile telecommunications terminal. It is inferred that this is because the empirical results are reflecting the ‘current’ consumers’ needs. Therefore, for the time being, until consumer needs change significantly, these implications should hold.

An additional advantage of using the mixed logit model is that it can represent the correlation between coefficients or marginal utilities of the attribute levels so that it can also represent a more realistic substitution pattern. Table 5 shows those correlations.

From Table 5 it can be seen that preference for ability to embody high-quality Internet and preference for high-level diversity and compatibility of application programs have a high positive correlation. This result coincides with expectations.

V. Discussion and Implications

How large should the display be? How portable should the future mobile device be?

As mentioned earlier, the preceding two questions are strongly correlated. Up to a point, display size is the most critical factor affecting the form factor of the mobile device. Accordingly, it affects portability almost linearly. Therefore, the two are analysed at the same time. From the estimation results,
A kind of consensus is found in the preference for a medium-sized display (88.85%), which means that there exists a certain optimum level for the display size and, at the same time, for the volume (portability) of the device. This result is significant for the future direction of device convergence. It implies that this kind of optimum display size and volume can be expected to be one of the major future directions of device convergence. Consequently, it can be presumed that the future mobile telecommunications terminal will have a volume, or size, similar to that of a current PDA or mobile phone while adopting a considerably large display.

Based on this, research and development should focus on increasing the number of pixels per area since that is one way to improve recognizability while maintaining portability. In the future, a hologram display or foldable display would be good research-and-development alternatives.

**What kind of input equipment will most likely be adopted?**

A keyboard with a trackball mouse is the most preferred kind of input equipment. This implies that a clear need exists for a convenient way to input letters directly. Accordingly, device convergence must be directed towards that. It also means that for input equipment, device convergence between the mobile terminal and the PC is preferable. On the other hand, compared with other input equipment, a keyboard entails a trade-off between portability and convenient inputting. Therefore, the convergent device needs to incorporate a keyboard while maintaining or improving portability. As used in the survey, a trackball mouse or infrared-ray-sensor mouse can be a very good means of support because either device improves the convenience of inputting data and of command while maintaining portability at almost the same level. In the future, a hologram keyboard will be an attractive alternative if the cost and technological problems can be managed.

Surprisingly, a touchscreen, the main input equipment of PDAs and smart phones now and considered one of the more probable types of input equipment of the future, is on average not preferred.

**Is it desirable for a future multiuse mobile terminal to support very diverse application programs? Is it desirable for it to be compatible with a PC?**

The study survey deals with the preceding two questions at the same time. The diversity and compatibility of application programs, used as an index for the performance and computing ability of the terminal, were not valued much by most respondents (79.25%). This means that for most people, the future mobile telecommunications terminal does not need to have high-level performance and or run diverse application programs if those amenities would cost more.

For device convergence, this implies that perfect convergence between the PC and the mobile device is not so desirable, and, as mentioned earlier, rather than perfect device convergence to one device, partial device convergence towards application-specific devices with only essential specifications for converged services will be more prevalent.

**What quality of Internet service should the future mobile device provide?**

This issue does not have much implication for device convergence itself, but a low level of preference for high-quality Internet service has important implications for other convergences. We discuss this later more in detail.

**To what extent will device convergence take place?**

Judging by the estimation results, a certain consensus for an optimum display size and volume (portability) exists. This may well be one of the major future directions of device convergence.

However, a large amount of heterogeneity in consumers’ preferences is found for other attributes, as shown in Section IV. Therefore, it can be inferred that partial device convergence is more probable than perfect device convergence. The stronger likelihood of partial device convergence means that the world may well see a main trend in portability and display size, but at the same time many diverse attributes meeting the various preferences of consumers may be embodied separately in many kinds of mobile devices. In that case, application-specific devices that are fitted to consumers’ diverse needs will be prevalent in the market.

**What effects will device convergence have on other convergences?**

Based on the finding of a low level of preference for high-quality Internet service, many kinds of services based on wire and wireless convergence, such as wireless LAN–mobile Internet roaming service, 2.3-gigahertz portable Internet service, and 3G Wide band Code-Division Multiple Access (WCDMA) mobile Internet service, may not quickly penetrate
the market upon introduction if they do not show consumers a clear difference from former Internet services. In addition, this finding suggests that if Next Generation communication Network (NGcN), a kind of network convergence, is aimed to provide mainly high-quality Internet service, introducing it too quickly to the market is not desirable. Rather, a gradual introduction after wire–wireless converged services are set down firmly will be more appropriate.

Given the finding of a higher preference for a medium-sized display, telecommunications–broadcasting convergence should prepare service content that is fitted to a medium-sized display on mobile devices. Although content can be realized very well on a large display, this service convergence will fail to attract consumers if it cannot guarantee good service quality on a medium display.

In light of the low level of preference for high device specifications, service convergence should be targeted to provide service content that can be realized at even low specifications. The opposite case also holds.

In addition, the extent of device convergence will affect service convergence and network convergence. A partial device convergence, which is very likely, will require service convergence to be targeted to provide service contents that can be easily transformed or standardized in order to be realized easily on many kinds of application-specific devices. This can have another meaning for network convergence. Now, NGcN is expected to be made based on an Internet protocol (IP) system. If it turns out to be the case, all application-specific devices can be operated compatibly under that system, and service content can be provided with ease.

VI. Conclusion

This study analyses how device convergence in mobile telecommunications will progress based on consumer preference estimates. For demand analysis, conjoint analysis and a mixed logit model were used to acquire information about the heterogeneity of consumers’ preferences.

The estimation results suggest that quite a lot of heterogeneity exists among consumers’ preferences, although a kind of consensus also exists for an optimum display size and degree of portability.

The results also show that rather than perfect device convergence toward one dominant device, one is more likely to see partial device convergence towards application-specific devices with an optimum display size and portability. In addition to the effect consumers’ preferences will exert on the main attributes of the device, they will significantly influence service convergence and network convergence as well.

References


**Appendix: Example of the Alternative Card Used in the Real Survey**

<table>
<thead>
<tr>
<th>No.</th>
<th>Input equipment</th>
<th>Quality of Internet</th>
<th>Diversity and compatibility of application programs</th>
<th>Display size</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Keypad</td>
<td>Low-quality Internet</td>
<td>Low level</td>
<td>Small</td>
<td>400 000 won</td>
</tr>
<tr>
<td>2</td>
<td>Touchscreen</td>
<td>Low-quality Internet</td>
<td>High level</td>
<td>Small</td>
<td>700 000 won</td>
</tr>
<tr>
<td>3</td>
<td>Keyboard</td>
<td>Low-quality Internet</td>
<td>High level</td>
<td>Large</td>
<td>550 000 won</td>
</tr>
<tr>
<td>4</td>
<td>Keyboard</td>
<td>High-quality Internet</td>
<td>Low level</td>
<td>Small</td>
<td>400 000 won</td>
</tr>
<tr>
<td>5</td>
<td>Keypad</td>
<td>High-quality Internet</td>
<td>Low level</td>
<td>Medium</td>
<td>700 000 won</td>
</tr>
</tbody>
</table>