Asian Journal of Innovation and Policy (2016) 5.002:185-196
DOI: http//dx.doi.org/10.7545/ajip.2016.5.2.185

Consumer Preferences for Digital Cable Broadcasting Service in Korea: A Choice Experiment Study

Se-Ju Ku[*], Seung-Hoon Yoo[**], Seung-Jun Kwak[***]

Abstract A digital cable broadcasting service is a multimedia broadcasting service that provides high definition and various supplementary services by using digital transmission. Korea implemented a complete digital broadcasting service by 2012. This study applied a choice experiment to investigate consumer preferences, and it calculated the marginal willingness to pay for this service. Moreover, we employed a multinomial probit model to relax the assumption that all respondents have the same preference for attributes being valued. The results suggest that respondents value channels, definition, video-on-demand (VOD) service, pay-per-view (PPV) service, and commerce based on TV (T-commerce). On the other hand, online gaming may be less important as an attribute for digital cable broadcasting service in Korea.

Keywords Digital cable broadcasting service, choice experiment, multinomial probit model, marginal willingness to pay

I. Introduction

A digital cable broadcasting service is a multimedia broadcasting service that provides high definition and various supplementary services by using digital transmission. The interest in digital broadcasting service had increased around the world. The United States completed its conversion to digital broadcasting service by June 2009. Japan and Europe phased out their analog broadcasting services by 2011 and 2012, respectively. Korea implemented a complete digital broadcasting service by 2012.

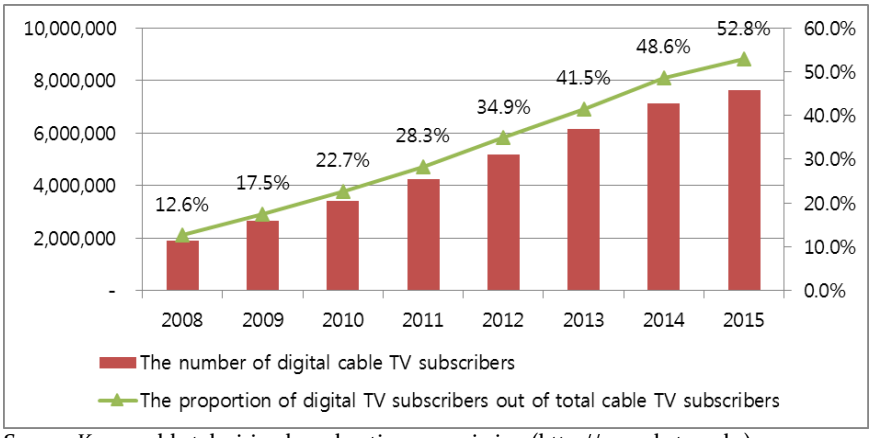
There are several reasons why countries considered the transition to digital broadcasting as an important national policy. First of all, digital signaling

Submitted, June 17, 2016; 1st Revised, July 22; Accepted, August 10
[*] Department of Economics, Korea University, 5-1 Anam-Dong, Sungbuk-Ku, Seoul, 136-701, Republic of Korea; +82-2-3290-2217; heroseju@korea.ac.kr
[**] Corresponding Author, Graduate School of Energy and Environment, Seoul National University of Science and Technology, 172 Gongreung-2-Dong, Nowon-Ku, Seoul, 139-743, Republic of Korea; +82-2-970-6802; shyoo@seoultech.ac.kr
*** Department of Economics, Korea University, 5-1 Anam-Dong, Sungbuk-Ku,Seoul, 136-701, Republic of Korea; +82-2-3290-2217; sjkwak@korea.ac.kr

offers much better picture definition and sound quality. The digital screen and sound quality are known to be five to seven times better than those offered by analog transmission. Digital broadcasting also makes it possible to experience various multimedia services with communication features that are transmitted through a digital format. With digital transmission, subscribers can experience an interactive two-way communication. Subscribers can provide input for their needs through television (TV), and can enjoy Internet surfing, shopping and gaming, all while watching TV.

From the perspective of the national economy, a digital broadcasting service stimulates investment and development of the next generation broadcasting technology, leading to economic growth. Moreover, the government would be able to manage the limited bandwidth more efficiently, freeing up space for future broadcasting and communication services.

Figure 1 shows the trend in the number of digital cable TV subscribers and the proportion of digital TV subscribers out of total cable TV subscribers in Korea. Both of them have dramatically increased. By the end of 2015, the number of digital cable TV subscribers reached 7.6 million households and the proportion of digital TV subscribers out of total cable TV subscribers in Korea had reached 52.8%.



Source: Korea cable television broadcasting commission (http://www.kcta.or.kr)

Figure 1 The number of digital cable television subscribers

A number of studies on broadcasting services have been conducted in Korea. Joo (2004) investigated users' attitude on the adoption factors of digital TV with regard to new media technologies. The results show no correlation between users' demographic characteristics and adoption factors, and respondents considered price as an important adoption factor. Kang et al.

(2005) analyzed the economic value of next-generation broadcasting, and showed that the economic values of Wireless Broadband (WiBro), Internet-based Wideband Code Division Multiple Access (WCDMA), Voice over Internet Protocol (VoIP), and Digital Multimedia Broadcasting (DMB) with WiBro were similar.

Koh et al. (2006) examined, through a conjoint survey, the types of attributes that critically affect competition among new convergence broadcasting services and how competitive they will be. The results of the study indicate that price is the most important factor for consumers, and it is expected that a considerable consumer valuation exists for the unique advantages of new convergence broadcasting services like mobility and two-way interactivity, which will add competitiveness of those services in the future. Choi et al. (2008) applied a Bayesian mixed logit model to conjoint survey data collected prior to the launch of Korea's two current types of mobile TV service (the satellite digital multimedia broadcasting and the terrestrial digital multimedia broadcasting) to investigate consumer preferences regarding the core attributes of mobile TV. The results imply that consumers regard subscription rates and media quality as the two most important attributes of mobile TV services.

This study applies a choice experiment (CE) to investigate consumer preferences for digital cable broadcasting services in Korea. The remainder of this paper is organized as follows. Section 2 reviews CE and its methodological issues. Section 3 presents statistical models to derive the willingness to pay (WTP) for digital cable broadcasting service. Section 4 discusses the results. The final section concludes.

II. Choice Experiment

The CE approach offers a promising opportunity to measure the various economic values of a digital cable broadcasting service, since it is concerned with modeling choices varying over a range of characteristics, rather than with the estimation of WTP for a single option. We identified six attributes: channels, definition, video-on-demand (VOD) service, pay-per-view (PPV) service, commerce based on TV (T-commerce), and online game. Table 1 describes these attributes, including price attribute, and shows how each level of attributes was defined.

CEs involve the use of the statistical design theory to construct choice sets which can yield coefficient estimates that are not confounded by other factors.

In this study, we employed the orthogonal main effects design[1] by using the SPSS 12.0 package. In the CE questions, there were three alternatives. Two represented a digital cable broadcasting service featuring combinations of attribute levels and specific price levels. The third alternative represented the status quo. Subsequently, there were $3^2 \times 2^{10} \times 4^2$ possible combinations of attributes and levels to form choice sets. Since it was impractical to ask respondents to choose from all the combinations, we drew a subset of all choice sets for estimating coefficients, and we drew eight choice sets. They were then randomly divided into two sets of four choices each. Figure 2 presents the example of the choice set that was actually used.

Table 1 Descriptions and levels of chosen attributes

Attributes	Descriptions	Levels
Channels	The number of broadcast network channels	120, 150, 200
Definition	Standard definition (SD) is the level same as analog broadcasting. Full high definition (Full HD) means the level same as watching movies in the theater.	Standard definition (SD) Full high definition (Full HD)
VOD	Instant delivery of requested video contents including latest films, TV dramas and educational contents	Not available (0) Available (1)
PPV	Purchase and watch the latest movie by unit	Not available (0) Available (1)
T-commerce	Purchase transactions while watching TV	Not available (0) Available (1)
Online game	Online gaming using TV	Not available (0) Available (1)
Price	Monthly service charges (except for additional charges pertaining to VOD, PPV, and T-commerce, etc.)	KRW 5,000 (USD 4.00) KRW 8,000 (USD 6.40) KRW 15,000 (USD 12.00) KRW 20,000 (USD 16.00)

To analyze the data, this study employs a multinomial probit (MNP) model. The previous discrete choice models have mostly used the multinomial logit (MNL) model, because MNL model has an advantage in that choice probability has a simple closed form. However, it has a serious drawback, known as the independence from irrelevant alternatives (IIA) property. To

[1] The orthogonal main effects design has been criticized by Street and Burgess (2010), since it does not guarantee uncorrelated parameter estimates. In a future study, we will try to investigate the work by Grossman, Holling, Grassoff, and Schwabe (2006), Kanninen (2002), and Street and Burgess (2010) to solve the problem, as an anonymous reviewer suggested.

rectify this problem, other advanced approaches can be applied, such as the generalized extreme value model (Train, 1986), the heteroskedastic extreme value model (Bhat, 1995), and the MNP model. Among these, the MNP model is most appealing because it allows the greatest flexible pattern of error correlation structure. This approach allowed the authors to relax the assumption that all respondents have the same preference for attributes being valued, which is usually required in empirical CE studies. The ability to model unobservable heterogeneous preferences in a population is a clear advantage of this technique (Layton, 2000).

	Alternative A	Alternative B
Channels	120	200
Definition	Full HD	Full HD
VOD	Available	Not Available
PPV	Available	Not Available
T-commerce	Not Available	Available
Online game	Not Available	Available
Price	KRW 5,000 (USD 4.0)	KRW 5,000 (USD 4.0)
Check with √ the only available alternative which you prefer among Alternative A, B or status quo.	☐ **A**	☐ **B**	☐ **Status quo**

Figure 2 A sample choice set used in this study

III. Model

1. Multinomial Probit Model

In this study, the random utility model was used to explain individual choices by specifying functions for the utility derived from the available alternatives. The indirect utility function for each respondent i who chooses alternative j in the choice set can be expressed as:

$$U_{ij} = V_{ij}(X_{ij}) + e_{ij} \tag{1}$$

The indirect utility function U_{ij} can be decomposed into the deterministic part V_{ij}, which is typically specified as a function of the attributes x_{ij} in alternative j chosen by respondent i, and the stochastic part e_{ij}, which represents the unobservable influence on individual choices. The MNP model assumes that the errors e_{ij}'s are distributed as multi-variate normal with mean vector zero and covariance matrix defined as follows:

$$\Omega = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_2^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_3^2 \end{bmatrix} \tag{2}$$

Consider the probability that the first alternative will be chosen.

$$\begin{aligned} \Pr(U_{i1} > U_{i2}, U_{i1} > U_{i3}) &= \Pr(e_{i2} - e_{i1} < V_{i1} - V_{i2}, e_{i3} - e_{i1} < V_{i1} - V_{i3}) \\ &= \Pr(\eta_{21} < V_{12}, \eta_{31} < V_{13}) \\ &= \int_{-\infty}^{V_{12}} \int_{-\infty}^{V_{13}} f(\eta_{21}, \eta_{31}) d\eta_{21} d\eta_{31} \end{aligned} \tag{3}$$

where

$\eta_{21} = e_{i2} - e_{i1}$, $\eta_{31} = e_{i3} - e_{i1}$, $V_{12} = V_{i1} - V_{i2}$, and $V_{13} = V_{i1} - V_{i3}$.

$f(\eta_{21}, \eta_{31})$ has a bi-variate normal distribution with covariance matrix Ω_1, which is transformed from Ω. We can identify the first diagonal element of the covariance matrix to one to add a property that a scale shift would not change observed choices. Ω_1 is given by:

$$\Omega_1 = \begin{bmatrix} \sigma_1^2 + \sigma_2^2 - 2\sigma_{12} & \sigma_1^2 - \sigma_{13} - \sigma_{12} + \sigma_{23} \\ \sigma_1^2 - \sigma_{13} - \sigma_{12} + \sigma_{23} & \sigma_1^2 + \sigma_3^2 - 2\sigma_{13} \end{bmatrix} = \begin{bmatrix} 1 & \theta_{23} \\ \theta_{23} & \theta_{33} \end{bmatrix}, \tag{4}$$

where $\theta_{23} = \dfrac{\sigma_1^2 - \sigma_{13} - \sigma_{12} + \sigma_{23}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}}$ and $\theta_{33} = \dfrac{\sigma_1^2 + \sigma_3^2 - 2\sigma_{13}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}}$.

The probability that second and third alternatives will be chosen can be similarly derived (Maddala, 1983).

2. Utility Function and Marginal WTP

The utility function of the model, with the exception of the error term, can be expressed as a linear function of an attribute vector $(Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7)$ = (Channels, Definition, VOD, PPV, T-commerce, Online game, and Price). We include two alternative-specific constants (ASCs), which represent dummies for respondent's choice of alternatives A and B in the choice set. ASC captures the utility of an alternative that attributes fail to capture (Adamowicz et al., 1994).

$$V_{ij} = ASC_j + \beta_1 Z_{1,ij} + \beta_2 Z_{2,ij} + \beta_3 Z_{3,ij} + \beta_4 Z_{4,ij} + \beta_5 Z_{5,ij} + \beta_6 Z_{6,ij} + \beta_7 Z_{7,ij} \quad (5)$$

where β's are parameters to be estimated for each attribute that influences respondents' utility. If we are calculating a marginal WTP (MWTP) from the status quo level of each attribute and assume that all other variables remain constant, we can obtain the following MWTP estimates by totally differentiating equation (5) and omitting i for brevity.

$$MWTP_{Z_k} = -(\partial V / \partial Z_k) / (\partial V / \partial Z_7) = -\beta_k / \beta_7, \quad for \;\; k = 1 \cdots 6 \quad (6)$$

The MWTPs of each attribute represent the marginal rate of substitution between the price and each attribute.

IV. The Results

A total of 800 face-to-face interviews were conducted over a month beginning December 2008. The survey was carried out in seven large cities: Busan, Incheon, Daegu, Daejeon, Gwangju, Ulsan, and Seoul. Since sampling and fieldwork were done by interview experts from a professional polling firm, Dongseo Research, Inc., the response rate is almost 100%. After missing and inconsistent answers to valuation questions were deleted, 731 (91.0%) individuals were found to be suitable for further examinations for this study, resulting in a total of 2,924 observations.

The sample demographics are similar to those of the target areas. Male respondents account for half the total sample. The average age and education level of respondents were 43.18 and 13.09 years, respectively. The sample was, thus, representative.

The estimation results of the MNP model are presented in Table 2. The model was estimated by the GHK simulation[2] (Geweke, 1989; Keane, 1994; Hajivassiliou and McFadden, 1998). Using the Wald statistic, estimated equations were found to be statistically different from zero at the 1% level.

Table 2 Estimation results

Variables[a]	Multinomial probit coefficient (*t*-values[c])
ASC_A[b]	-0.368* (-2.08)
ASC_B[b]	-0.738** (-2.78)
Channels	0.003** (4.54)
Definition	0.314** (4.04)
VOD	0.279** (3.71)
PPV	0.166** (4.10)
T-commerce	0.103* (2.12)
Online game	-0.113 (-1.68)
Price	-0.025** (-5.26)
θ_{23}	1.753** (6.81)
θ_{33}	0.233 (0.79)
Number of observations	2,924
Log likelihood	-3070.02

Notes: [a] The variables are defined in Table 1.

[b] ASC_A and ASC_B mean alternative-specific constants, which represent dummies for a respondent's choice of the alternatives A and B, respectively.

[c] * and ** indicate statistical significance at the 5% and 1% levels, respectively.

[2] MNP, in contrast to logit, allows for a flexible covariance structure, permitting correlations across alternatives and unequal variances across alternatives. The drawback of estimating an MNP model, however, is that it requires the evaluation of multiple integrals for which no closed form solutions exist. Specifically in the MNP case, for alternatives, multiple integrals of dimension must be calculated. This is hard and computationally intensive. The GHK simulator makes it possible to approximate the integrals required by MNP models. A recent exhaustive survey of probability simulators (Hajivassiliou, McFadden, and Ruud, 1996) reached a conclusion that the GHK simulator is the most reliable and accurate way to simulate multivariate normal probabilities for classical estimation.

Judging from the statistical results, the coefficients of all attributes, except online game, were significant, and their signs were consistent with our expectation. For instance, the coefficients of channels, definition, VOD, PPV, and T-commerce were positive. As the level of these attributes increases, the utility to respondents also increases. On the contrary, the coefficient of price attribute was negative and statistically significant. The higher the price, the lower the respondents' utility. However, the coefficient of online game was not statistically significant (i.e., this does not indicate that respondents place a significant value on this attribute).

To test whether the IIA property holds, a likelihood ratio test was carried out. The likelihood ratio test statistic follows asymptotically a chi-square distribution with one degree of freedom under the null hypothesis that errors are uncorrelated. The result of the IIA test rejected the null hypothesis that the errors are uncorrelated at the 1% significance level. Therefore, we cannot apply the MNL model which assumes that choices satisfy the IIA assumption. Since the MNP model does not require the IIA assumption, it is clear that the MNP model is a better model to estimate the data of this study.

The results of MWTP estimates are shown in Table 3. The respondents are willing to pay KRW 112 (USD 0.09) per one channel, and KRW 12,734 (USD 10.19) to change standard definition (SD) to full high definition (full HD). The results suggest that, if VOD, PPV, and T-commerce are available, respondents would be willing to pay KRW 11,301 (USD 9.04), KRW 6,753 (USD 5.40) and KRW 4,165 (USD 3.33), respectively.

Table 3 Marginal willingness to pay (MWTP) estimates and confidence intervals

Attributes	MWTP[a] (*t*-values[b])	95% confidence intervals
Channels	112** (5.48)	72 ~ 151
Definition	12,734** (4.78)	7,511 ~ 17,958
VOD	11,301** (3.50)	4,981 ~ 17,622
PPV	6,753** (3.87)	3,335 ~ 10,171
T-commerce	4,165* (2.25)	535 ~ 7,796
Online game	Not significant	-

Notes: [a] USD 1 equals approximately 1,250 Korean won.
[b] The *t*-values were computed using the delta method.
* and ** indicate statistical significance at the 5% and 1% levels, respectively.

To this end, the Monte Carlo simulation technique of Krinsky and Robb (1986) was used to generate 95% confidence intervals for MWTP. The 95% confidence intervals are presented in Table 3.

One of the strengths of CE is that the estimated coefficients of attributes may be used to estimate WTP for various scenarios in which the attributes can be combined. In this paper, three different digital cable broadcasting services were considered. Table 4 presents three hypothetical scenarios and the results of households' WTPs.

Table 4 Scenarios of digital cable broadcasting service (Korean Won)

Attribute levels	Scenario A	Scenario B	Scenario C
Channels	120	150	200
Definition	Full HD	Full HD	Full HD
VOD	Not available	Available	Available
PPV	Available	Not available	Available
T-commerce	Not available	Available	Available
Online game	-	-	-
Monthly WTP	32,873	44,932	57,263
Monthly WTP for all households in 7 cities	213 billion	291 billion	371 billion
Yearly WTP for all households in 7 cities	2,553 billion	3,489 billion	4,447 billion

With other conditions held constant, households' monthly WTPs for a digital cable broadcasting service such as scenario A, B, and C were approximately KRW 32,873 (USD 26.30), KRW 44,932 (USD 35.95) and KRW 57,263 (USD 45.81), respectively. Furthermore, WTPs for all households can be calculated by multiplying households' WTPs by the number of households. Since the survey of this study was conducted on households whose ages are between 20 and 65 in Busan, Incheon, Daegu, Daejeon, Gwangju, Ulsan, and Seoul, the authors used the number of households in those age brackets in the seven large cities. According to the Korea National Statistical Office, there were 6,471,247 households where ages ranged from 20 to 65 in 2005. The last two rows of Table 4 show the total WTP for households under each scenario. For example, households in the seven cities are willing to pay for KRW 4,447 billion (USD 3,557 million) for digital cable broadcasting service, which had the highest levels presented in this survey: 200 channels, full HD, VOD, PPV, and T-commerce. In similar fashion, we can make other scenarios using the attributes of digital cable broadcasting service.

V. Concluding Remarks

In this study, CEs were used to measure the potential value of each attribute in the Korean digital cable broadcasting service, and the MNP model was employed to relax the assumption of IIA. Overall, the survey was successful in eliciting MWTP values for a digital cable broadcasting service. Respondents' choices for selecting preferred alternatives were found to be within their own abilities, and the MWTP estimates were statistically different from zero, except for online game attribute. The results suggest that respondents value channels, definition, VOD, PPV, and T-commerce. On the other hand, online game may be less important as an attribute for the digital cable broadcasting service in Korea.

The monthly MWTP for one channel was calculated as KRW 112 (USD 0.09). The monthly MWTP for definition was calculated as KRW 12,734 (USD 10.19), and the household monthly WTP for VOD and PPV were KRW11,301 (USD 9.04) and KRW 6,753 (USD 5.40), respectively. In the case of T-commerce, MWTP was computed as KRW4,165 (USD 3.33). Households from seven cities in Korea are willing to pay approximately KRW 4,447 billion (USD 3,557 million) for a digital cable broadcasting service, which had the highest levels presented in this survey.

This study demonstrated the feasibility of extending the use of CE to digital cable broadcasting services. The results of this study provide a useful framework for incorporating such quantitative information in the evaluation of various policies with regard to digital cable broadcasting services.

Acknowledgement

An earlier version of this paper was presented at the 4th Africa-Asia-Australia Regional Conference of International Telecommunications Society, held in Perth, Western Australia during 16-18 August, 2009. The authors would appreciate the useful comments of discussants and the chairman.

References

Adamowicz, W., Louviere, J. and Williams, M. (1994) Combining revealed and stated preference methods for valuing environmental amenities, Journal of Environmental Economics and Management, 26, 271-292.

Bhat, C. (1995) A heteroscedastic extreme value model of intercity travel mode choice, Transportation Research, 29B, 471-483.

Choi, J.Y., Koh, D.Y. and Lee, J.S. (2008) Ex-ante simulation of mobile TV market based on Consumers' Preference Data, Technological Forecasting & Social Change, 75, 1043-1053.

Geweke, J. (1989) Bayesian inference in econometric models using Monte Carlo integration, Econometrica, 57, 1317-1339.

Grossman, H., Holling, H., Grassoff, U. and Schwabe, R. (2006) Optimal designs for asymmetric linear paired comparisons with a profile strength constraint, Metrika, 64, 109-119.

Hajivassiliou, V. and Mcfadden, D. (1998) The method of simulated scores for the estimation LDV models, Econometrica, 66, 863-896.

Hajivassiliou, V., McFadden, D. and Ruud, P. (1996) Simulation of multivariate normal rectangle probabilities and their derivative: theoretical and computational results, Journal of Econometrics, 72, 85-134.

Joo, C.M. (2004) A study on the adoption factors of potential users of the digital TV, Broadcasting research, 59, 199-225.

Kang, S.W., Cho, S.S. and Lie, H.Y. (2005) The economic value of next-generation converged communications and broadcasting services, ETRI Journal, 27(6), 759-767.

Kanninen ,B. (2002) Optimal design for multinomial choice experiments, Journal of Marketing Research, 39, 214-227.

Keane, M. (1994) A computationally practical simulation estimator for panel data, Econometrica, 62, 95-116.

Koh, D.Y., Lee, J.S. and Kim, T.Y. (2006) Forecasting future broadcasting service market based on the consumer preferences for the attributes of new convergence broadcasting services, Journal of Technology Innovation, 14(1), 227-255 (in Korean).

Korea Cable Television Broadcasting Commission, http://www.kcta.or.kr

Krinsky, I. and Robb, A. (1986) On approximating the statistical properties of elasticities, Review of Economics and Statistics, 68, 715-719.

Layton, D. (2000) Random coefficient models for stated preference surveys, Journal of Environmental Economics and Management, 40, 21-36.

Street, D. and Burgess L. (2010) The Construction of Optimal Stated Choice Experiments: Theory and Applications, Hoboken NJ: Wiley.

Maddala, G. (1983) Limited-Dependent and Qualitative variables in Econometrics, New York: Cambridge University Press.

Train, K. (1986) Qualitative Choice Analysis: Theory, Econometrics and an Application to Automobile Demand, Cambridge, Massachusetts: The MIT Press.