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A forecast simulation analysis of the next-generation DVD market based on consumer preference data

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Abstract

Just as standards wars over formats had characterized VCRs upon introduction to the market, the next-generation DVD standards war between Blu-Ray and HD-DVD lasted six years before Blu-Ray won the contest. Beginning with stated preference data drawn from a structured conjoint survey conducted before Blu-Ray became the de facto standard of the next-generation DVD format, we estimated consumer preferences on digital video players. A Bayesian mixed-logit model was used and market share simulations were conducted under various scenarios based on estimated parameters to surmise the future South Korean digital video-player market. Results indicate that consumers feel that network size and title availability are more important than hardware-related facets of the product, such as definition and storage capacity. The level of title availability and price of the Blu-Ray player for Blu-Ray's dominance over DVD will vary by the penetration rate of DVD players.

Keywords: next-generation DVD, de facto standard, mixed logit, market share simulation, standard competition

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1. Introduction

With the rapid changes in technology in recent years, standardization competition is becoming a key survival tactic. In fact, standardization competition is getting more intense and the strategy more complicated due to its unique characteristics, such as first-mover advantage and path dependence (among others). First-mover advantage, in particular, gives firms more of a chance to reign over competitors because it enables firms to enlarge their network size relatively easily.

Standards are defined largely into two categories: *de facto* standard and *de jure* standard (Farrell and Saloner 1988). The *de facto* standard is adopted after a standards war, where the market determines a sole standard. The *de jure* standard emerges through committee-based standardization, such as industry consensus or ratification by standards organizations. Although global standards have been mainly determined by international standards organizations such as the International Organization for Standardization and the International Telecommunication Union, *de facto* standards have also been shown to be very important, as in the cases of VHS, Windows, PDF, QWERTY (an optional layout for letters on a word processor), and other products for which the marketplace determines the standard.

A number of empirical studies regarding *de facto* standards have been undertaken. For example, with subtle differences in the time periods of the research and estimation models, researchers have used firm-level data to study *de facto* standardization of the VHS format in the US home VCR market and the estimated importance of network effects (Ohashi 2003; Park 2004). In addition, CD players (Gandal, et. al. 2000) and home video games (Shankar and Bayus 2003; Clements and Ohashi 2005) were also the subjects of empirical studies of the *de facto* standardization process. However, in spite of their rigorous estimation models based on strong theoretical backgrounds, methodologies of previous studies cannot be used directly in predicting the future standardization competition among newly emerged products because the former rely on revealed preference data.

Just as the standards war between VHS and Beta format, next-generation DVD formats, which enable consumers to enjoy high-definition video contents while maintaining disc sizes consistent with standard DVDs or CDs, have been the subjects of a severe and bloody standards war. The two combatants in this standards war are Blu-Ray, led by Sony, and High-Definition DVD (HD-DVD) discs, led mainly by Toshiba since 2002.

By getting a head start in the high-definition video market, the HD-DVD player had a first-mover advantage over Blu-Ray, but the trend changed completely after Sony launched PlayStation 3 (PS3), which functioned as a Blu-Ray player and gained the exclusive support of major Hollywood studios such as Disney. Convinced that software will play a crucial role in deciding the standardization contests, just as hardware had determined the winner of the standards war between VHS and Beta-max videotape formats, Sony devoted all its effort to gain exclusive support from major Hollywood studios, which had taken neutral stances and had been releasing movies in both HD-DVD and Blu-Ray formats. Finally, in January 2008, Warner Brothers, the only major studio still releasing movies in both HD-DVD and Blu-Ray format, announced it would release only in Blu-Ray after May 2008.

Warner Brothers' decision led to an abrupt chain reaction in the industry. Major US and

European retailers such as Wal-Mart and Woolworths announced that they would drop HD-DVD from their inventory. Following these new developments, on 19 February 2008, Toshiba finally announced it would end production of HD-DVD devices, allowing Blu-Ray to become the industry standard for high-density optical disks. Furthermore, shortly after Toshiba's announcement, Universal Studios and Paramount Studios, which had backed HD-DVD, announced the intention to release movie titles in Blu-Ray format, and Microsoft decided to cancel production of its HD-DVD drive for the Xbox 360.

However, all is not rosy for Blu-Ray format: A mighty competitor, DVD, already has a measurable size of the installed base. Although the Blu-Ray player is absolutely superior to the DVD player in technological aspects, DVD still has merits in terms of price, title availability, and the number of players that have already been sold. The deployment of next-generation DVD players might be delayed due to existing standards; DVD is in the similar kind of fight that existed in the music industry: The outcome of CDs versus LPs and cassette tapes took many years to resolve.

In March 2007, we conducted a structured conjoint (stated preference) survey of consumers, gathering opinions about several core and common attributes of digital video players, including DVD and next-generation DVD players. Our research data were collected before Blu-Ray became the *de facto* standard of next-generation DVD format.

As core attributes of digital video players, we chose price of player, definition, storage capacity, title availability, compatibility, network size, and format information of the digital video player. We used a Bayesian mixed-logit model to estimate basic consumer preference data, such as willingness to pay for each attribute, thus enabling the incorporation of consumer heterogeneity.

Besides the fundamental estimates, we conducted market share simulations of the competition among three technologies (Blu-Ray, HD-DVD, and DVD players) to verify our model. Although the standard of next-generation DVD format was set *de facto* (as Blu-Ray) such that a fierce standards war never broke out in the Korean digital-video market, we can conjecture the results of such a war from the simulated results. In fact, the simulation results based on the Korean market are analogous to the real results of standards wars in other countries such as the United States and Japan. Furthermore, we also conducted market-share simulations of the competition between two technologies (Blu-Ray and DVD players) by varying the levels of strategic variables; the results established a good strategy for Blu-Ray's fast and successful substitution of DVD.

The paper is organized as follows. In section 2, we review the model specification and simulation process. In Section 3, we describe the conjoint survey and its technique with the attributes and levels used in the survey and the sample selection. Basic estimation and simulation results by scenario are offered in Section 4, and we offer concluding remarks in Section 5.

2. Model specification

In this study, we employed a mixed logit model, which can accommodate heteroskedasticity of consumer preferences; that is, it is a type of random coefficient discrete-choice model. We used it to capture preference variation among individuals by

incorporating stochastic terms into the coefficients and allowing those terms to be correlated with each other.

We conducted the survey such that we lowered sampling costs while eliciting more and precise information from each respondent. First, each individual, n , in the survey was asked to rank the alternatives in order of preference among J alternatives in each of T choice sets, and second, we asked them to pick out the preferred alternative among T alternatives which they had chosen as best alternatives among J alternatives in each choice set. The respondent was then asked to carefully consider his/her own income level and indicate whether he/she would choose the alternative.

Thus, the utility of individual n , based on alternatives j in a choice set t , U_{njt} , can be denoted as follows:

$$(1) \quad \begin{aligned} U_{njt} &= V_n + \varepsilon_{njt} = \beta_n' x_{jt} + \varepsilon_{njt} = \beta_{price,n}' x_{price,jt} + \beta_{z_n}' z_{jt} + \varepsilon_{njt} \\ &= \beta_{price,n}' x_{price,jt} + \beta_{network\ size,n}' x_{network\ size,jt} + \beta_{q_n}' q_{jt} + \varepsilon_{njt} \end{aligned}$$

where x_{jt} denotes the vector of attributes associated with alternative j in choice set t ; β_n shows the vector of the attributes' coefficients, which are distributed as multivariate normal with b mean and variance covariance matrix W , $\beta_n \sim N(b, W)$; ε_{njt} is a random disturbance having a logistic distribution; z_{jt} is the vector of the attributes associated with alternative j except the price variable; q_{jt} is the vector of the attributes associated with alternative j except the price and network size. Especially, the network size denotes the installed base of alternative j and β_{z_n} and β_{q_n} represent the coefficients of those variables respectively.

Although the distributions of parameter (the distribution of the coefficients of attributes) are easy to set up in a normal distribution, Train and Sonnier (2005) suggest that distributions of parameter be set by the characteristics of the attributes that influence the consumer's utility. For instance, they suggest that it is appropriate to set the distributions as a log normal (bounded below by zero) distribution for the parameter of attributes that are liked by all customers. Of course, the sign can be reversed for undesirable attributes, such as a price variable, so that the parameter is necessarily negative. Thus, the utility function, which reflects the transformation process of the distribution of β_n from a normal distribution to a log-normal distribution, can be denoted as follows:

$$(2) \quad U_{njt} = C(\beta_n)' x_{jt} + \varepsilon_{njt}$$

In addition, the likelihood function of individual n , which consists of the likelihood function of individual n 's observed sequence of ranking and binomial choice on the

most-preferred alternative m among the total $T \times J$ alternatives, can be denoted as follows:

$$(3) \quad L(r_n | \beta_n) \cdot L(d_n | \beta_n) = \left(\prod_{t=1}^T \prod_{j=1}^{J-1} \frac{e^{C(\beta_n)'x_{jt}}}{\sum_{k=j}^J e^{C(\beta_n)'x_{kt}}} \right) \cdot \left(\frac{e^{C(\beta_n)'x_{mt}}}{1 + e^{C(\beta_n)'x_{mt}}} \right)$$

where $r_n = \{r_{n1t}, \dots, r_{nJt}\}$ denotes the vector of individual n 's ranking responses in choice set t in descending order of preference, with T being the total number of choice sets; d_n shows individual n 's binomial choice on the most-preferred alternative m among the total $T \times J$ alternatives.

We employed the Bayesian process instead of a traditional maximum likelihood estimation method (MLE). Although both estimation processes are available in the mixed logit model, the Bayesian estimation has advantages over the classical approach. Through use of the Bayesian approach, we not only escape the computational burden of calculating the integration of multivariate (normal) density functions, but the model does not suffer from the global maximum problem which does not guarantee convergence of the maximum likelihood estimation to a global maximum and is critical to the location of the starting point by avoiding direct evaluation of the nontrivial likelihood function. At the same time, we can interpret the results of the Bayesian procedure simultaneously from both the Bayesian and classical perspectives (Train and Sonnier 2005). That is, the mean and covariance of the Bayesian posterior is asymptotically equivalent to the mean and covariance estimated by the MLE method, respectively. Moreover, compared with the classical method, the Bayesian procedure can easily induce desirable estimation properties, such as consistency and efficiency, under more relaxed conditions (Train 2003).

Besides the fundamental estimates, we can deduce quantitative figures that have strong policy or economic implications using the β_n samples taken from the retained draws of b s and W s in the Bayesian process. We can calculate the relative importance of each attribute k and consumers' median marginal willingness to pay (MWTP) in each attribute; that is, the change in the compensating variation is associated with a change in a one unit increase of each attribute as follows:

$$(4) \quad \text{Average Relative Important Percent of Attribute } k = \frac{1}{N} \sum_{n=1}^N \left(\frac{\text{part worth}_{nk}}{\sum_k \text{part worth}_{nk}} \times 100 \right)$$

$$\text{part worth}_{nk} = \text{interval of attribute } k\text{'s level} \times C(\beta_n)$$

$$(5) \quad \text{Median } MWTP_z = \text{Median} \left(-\frac{\partial U_n / \partial z_n}{\partial U_n / \partial p_n} \right) = \text{Median} \left[-\frac{C(\beta_{z_n})}{C(\beta_{price,n})} \right]$$

where part worth_{nk} is the difference between each attribute's highest and lowest part worth. The term indicates the impact of changing the attribute level within a particular attribute.

Furthermore, using the following equation, based on various and specific market situations where several alternatives compete, we can simulate the probability that a given alternative is chosen (Choi, et. al. forthcoming):

$$(6) \quad P_j = \frac{1}{N} \sum_{n=1}^N I(U_{nj} > U_{nk} \quad \forall k \neq j) = \frac{1}{N} \sum_{n=1}^N I[C(\beta_n)'x_j + \varepsilon_{nj} > C(\beta_n)'x_k + \varepsilon_{nk} \quad \forall k \neq j]$$

where $I(\cdot)$ is the indicator function, equaling 1 when the expression in parentheses is true; it is 0 otherwise. That is, $I(\cdot)$ is 1 only when alternative j provides the greatest utility to individual n . See Fig. 1.

[Insert Figure 1]

However, unlike Choi's previous research (Choi, et. al. forthcoming), the utility function in this study incorporates network size as an explanatory variable, which has identical meaning to the P_j , the probably of an alternative choice in Eq. 6. Thus, the simulation process lasted until these the two variables are identical for all j s. The detailed iteration process of the iterative market-share simulation is depicted in the Fig. 1. Where r denotes number of iterations, and the tolerance level, a criteria of convergence, is 10^{-3} .

3. Survey and data

In this study, we employed a conjoint survey to collect the stated-preference data. A conjoint survey asks respondents to rank choices from hypothetical service alternatives that feature various combinations of attributes of goods and services. It has a couple of major advantages in enabling the researcher to estimate consumers' preferences for nonexisting alternatives and avoiding collinearity among the core attributes. Namely, it allows the researcher to design experiments containing as much variation in each attribute as he or she thinks is appropriate. For this reason it has been widely applied in various research fields, such as general marketing (Huber and Train 2001), transportation research (Hensher 2001), environmental economics (Roe, et. al. 1996; Layton 2000), and now even in new high-tech applied items and services such as information technology (IT) products (Batt and Katz 1997; Kim, et. al. 2004) and IT services (Choi, et. al. forthcoming; Byun, et. al. 2004; Kim, et. al. 2006; Ahn, et. al. 2006).

Dongseo Research, a leading market-research firm, conducted the conjoint survey for

our study in Seoul, South Korea, in March 2007. It was administered to 1,000 adults ranging in age from 20 to 60 years. To improve reliability of the results, well-trained specialists administered the surveys through one-on-one direct interviews, and a pilot test was carried out so we could select the critical attributes and levels. To draw a random sample of the population, we divided Seoul into four districts (north, south, east, and west) and performed stratified random sampling within each district. This method yields characteristics reflective of the population, such as age, sex, and occupation, with reasonable accuracy.

We decided on the following as core attributes: price of player, definition, storage capacity of media, title availability, compatibility, network size, and format information. Using the core attributes and their levels, we composed hypothetical alternative cards depicting various kinds of digital video players, including DVD and next-generation DVD players. The attributes and their respective levels are shown and explained in Table 1.

[Insert Table 1]

Respondents were given visual illustrations of the attributes along with a detailed explanation of the differences in definition among quality analogue TV, standard definition (SD), and full high definition (Full-HD). Because the number of alternative cards derived from the theoretical combinations of the six attributes (i.e., $3 \times 3 \times 3 \times 3 \times 2 \times 3 \times 2 = 972$) is prohibitively large, we chose 18 alternative cards from a fractional factorial design test. In addition, we divided the 18 alternative cards into 6 subalternative card sets because of the respondents' tendencies to evaluate the lower-ranking alternatives trivially. Moreover, as mentioned in Section 2, we also asked respondents if they will actually buy the most-preferred alternative among six alternatives that were chosen as a best alternative among three in each choice set. We asked them to make their decision based on careful consideration of their income so that they would not provide a careless evaluation.

4. Results and discussion

As noted in Section 2, model specification, we assumed the type of distribution of each attribute coefficient by considering the characteristics of the attributes affecting consumer preference. Because the attributes in this study (except one, format information) are expected to be liked or disliked by all consumers, the parameters of them were assumed to have a log-normal distribution. Specifically, the sign of the coefficient of price of player was assumed to be negative because any increase in price would be considered undesirable and disliked by all consumers. The coefficients of the remaining five attributes were assumed to have a positive sign. However, the coefficient of the two dummy variables that represent format information, HD-DVD and BRD, were assumed to have a normal distribution.

While conducting Bayesian estimation, we generated 20,000 draws with Gibbs sampling. We discarded the first 10,000 draws because we considered them indicative of a "burn-in" period where the chain may not have converged. We retained every 10th

draw from the retained, second, 10,000 draws because sequential draws may be highly correlated (Geyer 1992). Using the retained 1,000 draws of b s, we took another 2,000 draws of β_n from a normal distribution with the mean equal to the estimated value of b and the variance equal to the value of W . Each draw of β_n was then transformed to obtain a draw of coefficients.

As Table 2 shows, all the transformed estimated means of β_n are statistically significant at the 1% level. The results of relative importance show that consumers find nearly all the attributes except compatibility and those associated with two dummy variables, HD-DVD and BRD, as important facets of digital video players.

[Insert Table 2]

Although the hardware-related attributes (which are considered the strongest motivations for using the next-generation DVD player), definition and storage capacity of media, are still important facets, the sum of their relative importance is only 27.59%. However, the sum of the relative importance of network size and title availability, which represent the installed base and indirect network size, is 38.77%. Considering that the improvements of the attributes that are directly related to the technology cannot be easily achieved, software and network size, represented by number of released title and sales of player, will play a crucial role in the successful deployment of next-generation DVD.

Using the estimated coefficients, we calculated the MWTP (i.e., the variation in compensation associated with a one-unit increase of each attribute) for each attribute of individual n , and we obtained the MWTP distribution for each attribute from the aggregation of the MWTP values from each person.

The median MWTP estimates for each attribute, derived using Eq. 5, are shown in Table 2. The estimated median MWTPs for definition, storage capacity of media, title availability, and network size are 14,325 won/76,800 pixels (US\$15.11/76,800 pixels), 15,025 won/GB (US\$15.85/GB), 8,869 won/% title availability (US\$9.36/% title availability) and 19,801won/% of the network (US\$20.89/% of the network) respectively.

Table 3 shows how the Blu-Ray, HD-DVD, and DVD players stack up in terms of the seven core attributes. In technological aspects, definition and storage capacity, next-generation DVD players are absolutely superior to DVD, but DVD players have the compatibility advantage. Although Blu-Ray and HD-DVD look similar in many aspects, there are technological differences between them. Because Blu-Ray utilizes a lens with a greater numerical aperture than does HD-DVD, the laser spot can be focused with greater precision to fit more data on the same size disc, which allows Blu-Ray to hold 25GB (50GB on a dual-layer disc), whereas HD-DVD can only hold 15GB per layer (30GB on a dual-layer disc).

[Insert Table 3]

Besides technological differences among three alternatives, huge differences characterize the other core attributes: price of player, title availability, and network size. Currently, despite some variations, the normal price of HD-DVD and Blu-Ray players, as represented by Xbox360 and PS3, ranges from nearly 200,000 won (US\$210.97) and 350,000 won (US\$369.20) in Korea (March 2008). The price of a standard DVD player is only one-third the price of HD-DVD and Blu-Ray. Moreover, available released titles and sales of both next-generation DVD players are still rare due to the past format war.

The DVD player not only boasts high title availability but a measurable penetration rate. Although the penetration rate of DVD players is low in Korea,¹ in many other advanced countries, the penetration rates of the DVD player are high. For example, in 2006, Japan and the United States had a penetration rate of 61.1% (Ministry of Internal Affairs and Communications in Japan 2006) and 81.2 % (Nielsen Media Research 2006) respectively. Consequently, despite of its technological inferiority to the next-generation DVDs, the current DVD players can be a mighty competitor to the next-generation DVD players, not an obsolescent technology that will perish in a short time; to maintain the edge over next-generation DVD players, however, current DVD players must maintain the advantage in price, available number of titles, and network size.

Thus, the following two cases are studied: the competition between three technologies (Blu-Ray, HD-DVD, and DVD players) and two technologies (Blu-Ray and DVD players) assuming that these are the available alternatives in the South Korean digital video-player market with no alternative. We surmised the market share of each alternative by substituting the seven core attribute levels for each service, as denoted in Table 3, into Eq. 6 and iterating this process until the probability of each alternative choice was identical to its network size as illustrated in Fig. 1.

4.1. Competition among Blu-Ray, HD-DVD, and DVD players

Fig. 2 illustrates how the market share of each alternative varies when title availability of Blu-Ray varies from 10 to 90% and the network size (i.e., penetration rate) of the DVD is 25%. We also assumed that title availability of Blu-Ray is equal to 100% minus the percentage of title availability for HD-DVD; that is title availability is based on the percentage of major movie studios that release titles exclusively in only one format (i.e., HD-DVD or Blu-Ray).

[Insert Figure 2]

As a result, when more than 50% of total released movies are in Blu-Ray format (i.e.,

¹ Some statistical figures on the DVD player penetration rate were available on the Korean market until 2004. (Samsung Electronics' survey in 2004 denoted that the penetration rate of the DVD player in Korea was approximately 15 to 21%). However, recent statistic figures or estimates on the penetration rate of the DVD player in Korea are rare or nonexistent. In our survey, conducted in March 2007, 25.5% of the respondents owned a DVD player.

less than 50% of total released movies are on HD-DVD), Blu-Ray dominates the South Korean digital video-player market. However, if less than 30% of total released movies are in Blu-Ray (i.e., more than 70% of total released movies are in HD-DVD), HD-DVD dominates South Korean digital video player market. Of particular note, if the balanced competition continues, that is, Blu-Ray and HD-DVD secures 40 and 60% of total released movies respectively, next-generation DVD formats cannot successfully succeed to today's DVD format.

The HD-DVD player could not be included in the future alternative-choice set of digital video players because Toshiba is ending its production of HD-DVD devices. Fig. 2 explains the reasons for the Toshiba decision. After Warner Brothers declared that its titles would appear only in Blu-Ray format, six of the other eight major movie studios also exclusively supported Blu-Ray; only Universal supports HD-DVD. More than 70% of released titles will be on a Blu-Ray player only if the movie studio backing Blu-Ray releases movie titles as a format of Blu-Ray just like DVD. This means that the movies currently on DVD issued by movie studio backing Blu-Ray will be reissued on Blu-Ray.

4.2. Competition between Blu-Ray and DVD players

To deduce economic and management implications, we simulated how the market shares of Blu-Ray and DVD players, as sole alternatives with no alternative, would vary by controlling two major strategic variables: price of and title availability associated with the Blu-Ray player. The support from the major movie studios does not necessarily mean that enough Blu-Ray movie titles will be released; stand-alone movie titles must also be released on Blu-Ray for the Blu-Ray player to be a substitute for the DVD player.

As seen in Fig. 3, Fig. 4, and Fig. 5, the title availability necessary for Blu-Ray dominance over DVD dramatically varies by the current network size (i.e., penetration rate) of DVD. When the network size of DVD is low (25%), only 40% of total movie titles need to be released in Blu-Ray format for Blu-Ray to dominate DVD. However, as the network size of DVD grows to 50 and 75%, between 60 and 70% of total movie titles need to be released in Blue-Ray format for Blu-Ray to dominate DVD.

[Insert Figure 3, 4 & 5]

We deduced the effect of Blu-Ray player price on the market share of Blu-Ray. The market share simulations were conducted under the assumptions that Blu-Ray has either 70 or 100% of the total released titles.

In the case that 70% of the released titles are in Blu-Ray format, the price needed for Blu-Ray players to dominate the DVD player varies by the network size of DVD player. As a result, when the network size of DVD player is small, 25%, the Blu-Ray player remains dominant over the DVD player even though its price rises to 600,000 won (US\$632.91). However, as seen in Fig. 6 and Fig. 7, which illustrate the simulation results, when the network size of the DVD player grows to 50 and 75%, the price of the Blu-Ray player should be lowered to 350,000-400,000 won (US\$369.20-421.94) and

300,000-350,000 (US\$316.46-369.20), respectively, for Blu-Ray to maintain dominance over DVD.

[Insert Figure 6 & 7]

However, if the stand-alone movie titles are issued on Blu-Ray to the level that they are currently made available for the DVD player (i.e., 100%), the Blu-Ray player will successfully substitute today's DVD player even though Blu-Ray is expensive and the network size of the DVD player is high. In fact, as shown in Fig. 8, even when the price of the Blu-Ray player rises to 600,000 won and the penetration rate of the DVD player is 75%, the Blu-Ray player dominates the DVD player in market share only if Blu-Ray has 100% title availability.

[Insert Figure 8]

5. Concluding remarks

To investigate consumer preferences regarding the core attributes of next-generation DVD, we applied a Bayesian mixed-logit model to structured conjoint-survey data obtained before Blu-Ray became the de facto standard of the next-generation DVD format. The results show that consumers regard network size and title availability, which represent installed base and indirect network size, as more important than hardware-related attributes, definition and storage capacity of media, which are considered the strongest motivators for using the next-generation DVD player. The estimated median MWTPs for definition, storage capacity of the media, title availability, and network size are 14,325 won/76,800 pixels (US\$15.11/76,800 pixels), 15,025 won/GB (US\$15.85/GB), 8,869 won/% title availability (US\$9.36/% title availability) and 19,801 won/% of network (US\$20.89/% of network) respectively.

Despite the existence of a number of empirical studies regarding de facto standardization, the other methodologies are not appropriate for predicting the future standards competition in that they require revealed preference data. Thus, on a solid base consisting of the fundamental estimates using stated preference data collected from a well-designed structured conjoint survey, we conducted market-share simulations under two kinds of competitions: among three technologies (Blu-Ray, HD-DVD, and DVD players) and between two technologies (Blu-Ray and DVD players).

We assumed that among the three technologies the title availability of Blu-Ray is equal to 100% minus the title availability of HD-DVD. The market-share simulation results show that Blu-Ray will dominate the South Korean digital video-player market only if 50% of the released movies are in Blu-Ray format. In fact, the main producer of HD-DVD devices, Toshiba, ended its production after the Warner Brothers announced the exclusive release of its titles only in Blu-Ray format, which verifies the estimation results and process.

As for the market share simulations in the competition between Blu-Ray and DVD players, we based the estimates on varied core strategic variables: price of the Blu-Ray

player and title availability of Blu-Ray at different levels of the DVD installed base. The results show that when the network size of DVD grows from 25% to 50 and 75%, the minimal needed title availability for Blu-Ray's dominance over DVD varies from 40% up to 60 and 70%, respectively. Because 70% of total released titles are in Blu-Ray format, when the network size of DVD grows from 25% up to 50 and 75%, Blu-Ray remains dominant only the price of Blu-Ray player lowers from above 600,000 won (US\$632.91) to around 350,000-400,000 won (US\$369.20-421.94) and 300,000-350,000 (US\$316.46-369.20). Only if stand-alone movie titles are released in Blu-Ray at the level that they are currently available for the DVD player (i.e., 100%) will the Blu-Ray player dominate the DVD player; this is the case even though the DVD player already has a high-installed base (75% penetration rate) and the price of the Blu-Ray player is as much as 600,000 won (US\$632.91).

In summary, we believe that our market share simulations conducted with Bayesian mixed-logit estimation and stated preference data collected from a structured conjoint survey can provide accurate and ample information in understanding consumer behavior on the next-generation DVD format and forecasting the future of the digital video-player market. Furthermore, this methodology can be applied any other products subject to de facto standardization where strong network effects are expected to exist. We hope that both the estimation results and the methodology itself presented herein can inform the decisions of business and government alike.

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Table 1.

Attribute	Explanation	Level
Price of player (10,000 won)	Price of the digital video player	20, 50, 100
Definition	<p>Quality of Analogue TV: $320 \times 240 = 76,800$ pixels</p> <p>Standard definition (SD): 4.5 times higher resolution than that of Quality of Analogue TV: $720 \times 480 = 345,600$ pixels</p> <p>Full High Definition (Full-HD): Highest available picture quality, 27 times higher resolution than that of quality of analogue TV: $1920 \times 1080 = 2,073,600$ pixels</p>	1, 4.5, 27
Storage capacity of media (Gigabyte:GB)	Storage Capacity that the media disc holds	10, 30, 50
Title availability (%)	Available stand-alone movie titles among the total released on the assumption that current the DVD format has been used for 100% of released titles	50, 80, 100
Compatibility	Can the digital video player accommodate currently released DVD titles?	Yes/No
Network size (%)	Penetration rate of digital video player: people who retain a digital video player at home	10,30,50
Format information	Format information denotes other information of the digital video player except the six core attributes chosen in this study. Dummy variables HD-DVD and BRD denote the following information: HD-DVD is a format developed by Toshiba and adopted in Microsoft Xbox360, and BRD is a format that is developed by Sony and adopted in its PS3.	HD-DVD /BRD

Note: According to the Bank of Korea, 948 Korean won equaled approximately US\$1 during the survey period (March 2007).

Table 2.

Attribute	Mean	Average Relative Importance Percent (%)	Median MWTP
Price of player	-0.0194**	21.57	
Definition	0.0316**	11.67	14,325 (won/76,800pixel)
Storage Capacity Of media	0.0333**	15.92	15,025 (won/GB)
Title availability	0.0345**	16.20	8,869 (won/% of available titles)
Compatibility	0.0349**	0.61	13,120 (won)
Network size	0.0398**	22.57	19,801 (won/% size of network)
HD-DVD	0.0165**	5.52	12,225 (won)
BRD	0.0211**	5.94	12,753 (won)

** Significant at 1%.

Table 3.

Attribute	Blu-Ray Player	HD-DVD Player	DVD Player
Price of player (10,000 won)	35	20	10
Definition	Full-HD	Full-HD	SD
Storage capacity of media	50.0 GB	30.0 GB	8.4 GB
Title availability	~10–100%	~10–100%	100%
Compatibility	Compatible	Compatible	Compatible
Network size	0%	0%	25/50/70%
HD-DVD	0	1	0
BRD	1	0	0

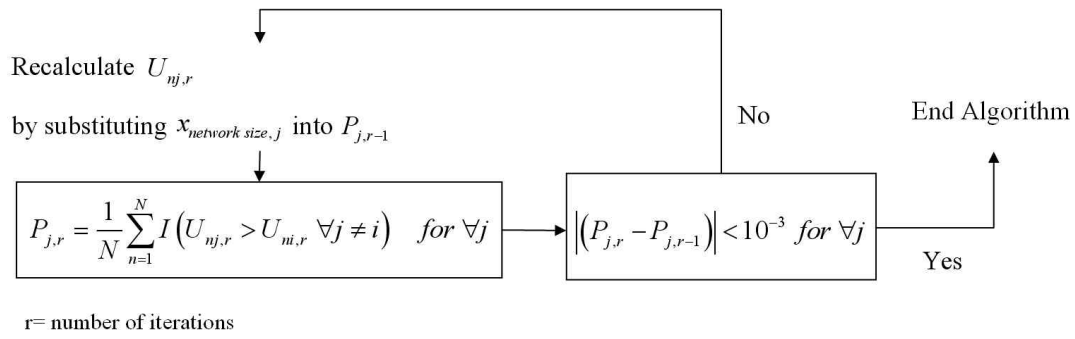


Figure 1.

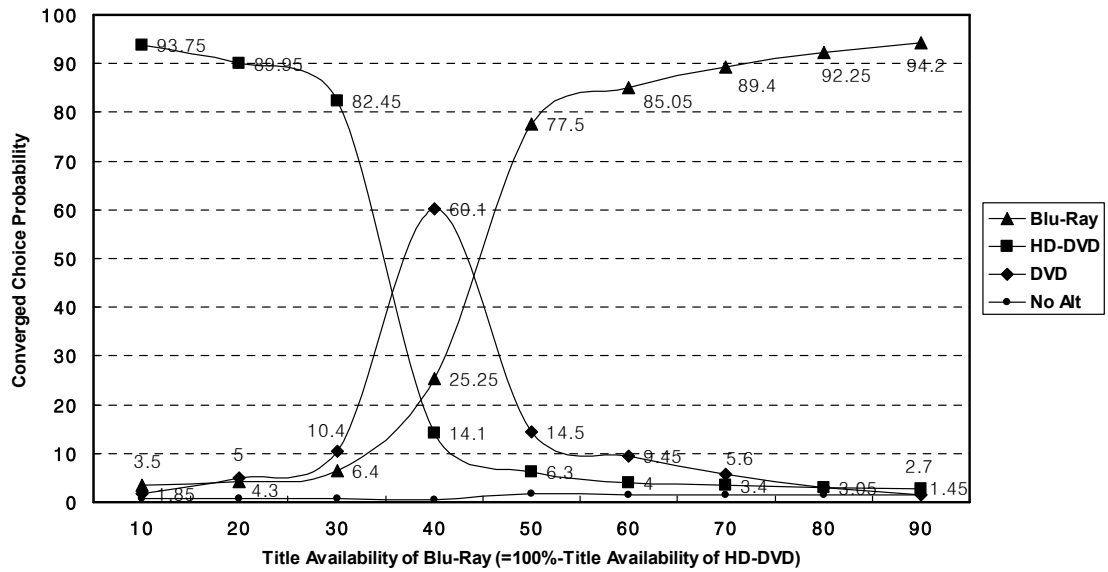


Figure 2.

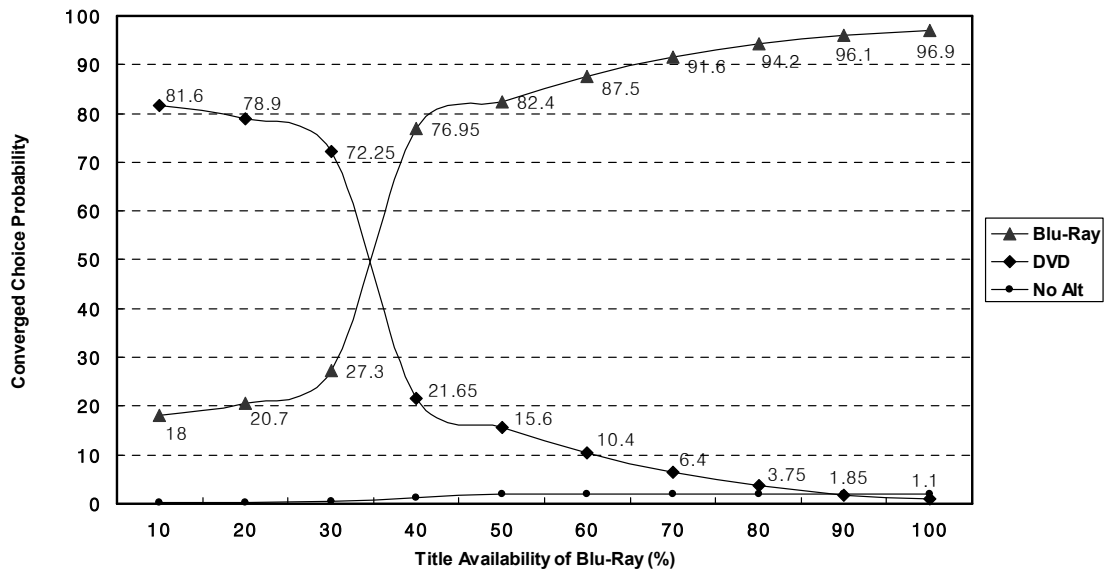


Figure 3.

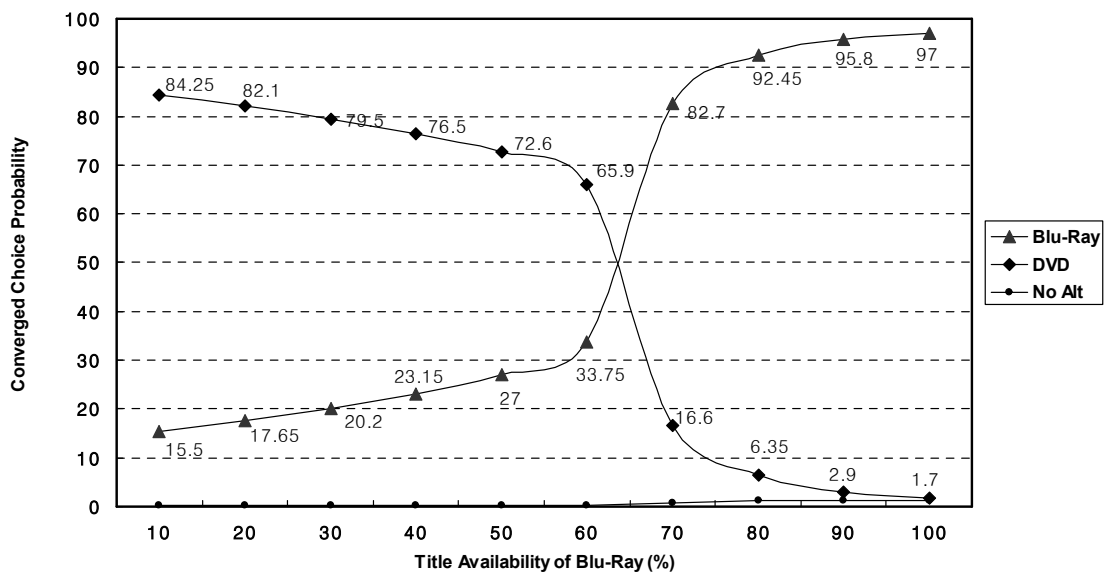


Figure 4.

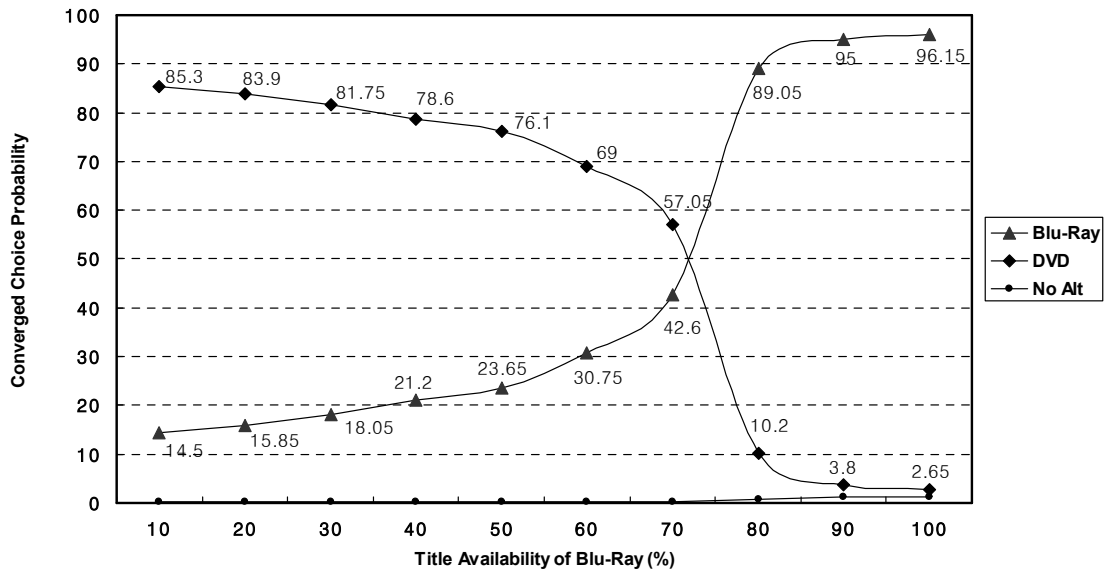


Figure 5.

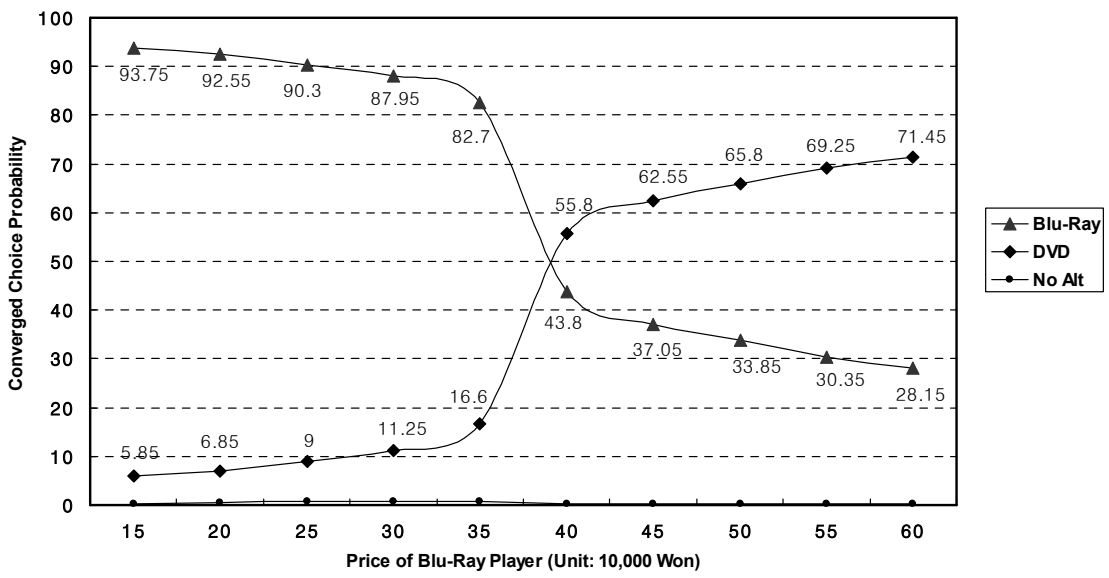


Figure 6.

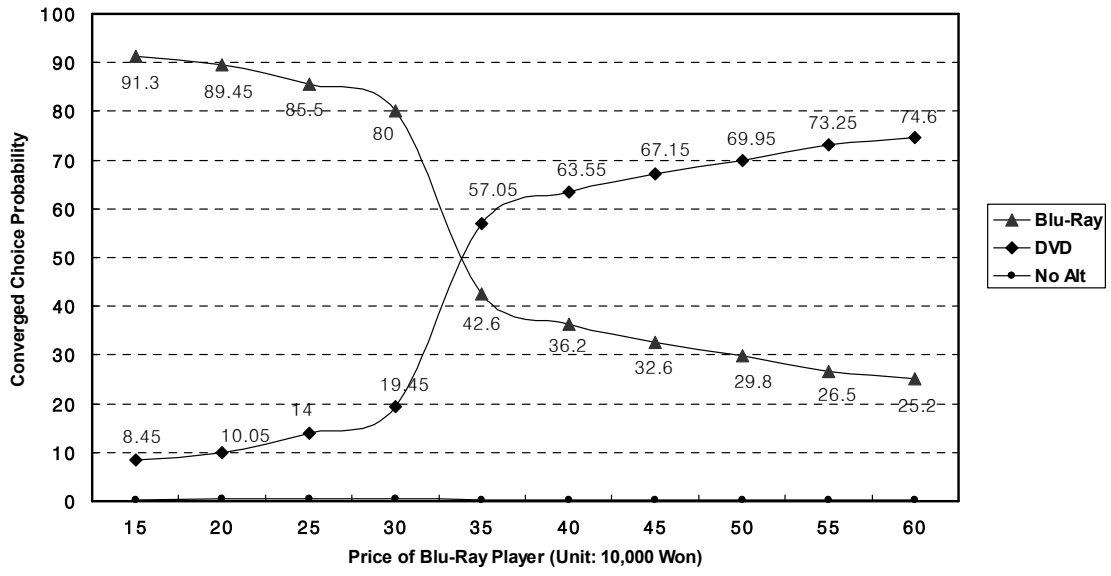


Figure 7.

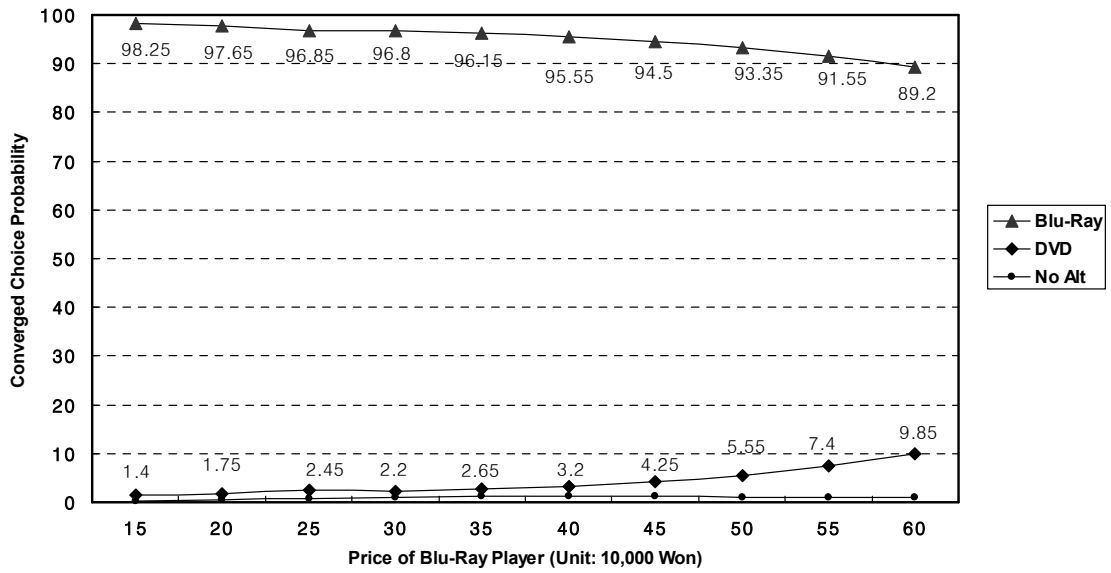


Figure 8.

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