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# Online advertising by the comparison challenge approach

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**Abstract**

To enhance the effectiveness of online comparisons from a manufacturer's point of view, we develop a framework for the comparison challenge approach. To develop the comparison challenge framework, we analyze 12 factors that determine the characteristics of comparison and propose models of valuable comparison challenges using the *CompareMe* and *CompareThem* strategies. We demonstrate the approaches with the example of PC selection. To help plan the comparison challenges, we formulate a mathematical programming model that maximizes the total value of comparison under the constraints of comparison opportunity and budgetary limitation. The model is applied to eight comparison scenarios, and its performance is contrasted with the view of balancing long-term perspective and short-term revenue increase. The performance of the comparison challenge approach is contrasted with those of random banner and similarity-based comparison approaches, and shows a substantially higher effect.

*Keywords:* Comparison shopping; Comparison challenge; Online advertisement; Ad planning; Electronic commerce

## 1. Introduction

Internet advertisement has become very popular for the promotion of online sales [1,2]. Internet advertising revenue in the US has grown from $8.23 billion in 2000 to $12.5 billion in 2005 [3]. According to a survey conducted by the American Advertising Federation [4], the percentage of media budgets allocated to online advertising represented 14.1% in 2005, a figure that is projected to hit 19.1% by 2006.

To sell products on the Internet, it is common for manufacturers to advertise their models in banners and comparison tables at third-party comparison portal sites such as shopping.com, shopper.cnet.com, pricegrabber.com, and mysimon.com [5]. Since many customers visit comparison sites before they decide what to order, the online comparison can be used as an important channel of advertisement [6,7]. In those sites, the Internet ads may take various approaches, such as *banners as arbitrary reminder*, *personalized banners as relevant reminder*, and/or *tabular comparison*.

When a manufacturer designs a new product, it usually considers targeting competitors' models to beat the competitors in terms of performance and/or price, particularly when the manufacturer is not the major market leader. For instance, a specific model of notebook PC has competing models that are produced by the market leaders. When a new model is developed that can outperform the competitors' models, the manufacturer is eager to demonstrate this comparison to customers who are viewing the competing models. In the traditional comparison site, however, the manufacturer has no control over how the comparison is displayed. So it is desirable for the manufacturer to have an opportunity to invoke *Comparison Challenges*. The *CompareMe Challenge* can be triggered when a customer browses a competitor's model, while the *CompareThem Challenge* can be triggered when the customer browses the manufacturer's own model [8,9]. In either case, the basic brand power and trust in the manufacturer and information provider will be required to attract the customer's

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attention and encourage the customer to click on the comparison [10,11].

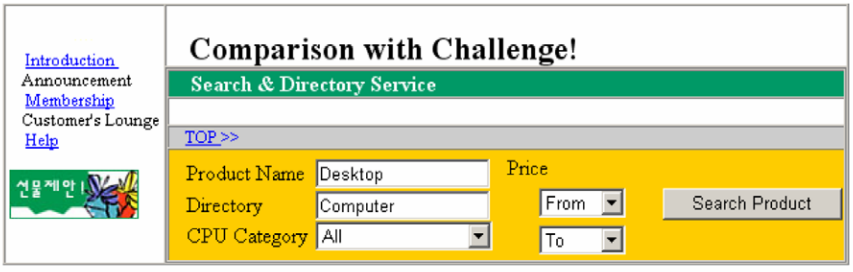
Suppose the performance and price of a product outperform those of the competitor's displayed item. As illustrated in Fig. 1, the manufacturer will be eager to shout "Compare Me!". To be more informative, the term "Me" may be replaced by the specific name of the company or model. Since the comparison will precisely contrast the performance and price, the manufacturer will not be motivated to challenge another product unless their products are competitive in at least certain respects. This implies that the burden of unnecessary comparison can be screened out by the nature of the comparison challenge. Thus we can expect that the comparison will be more relevant, informative, and timely than traditional tabular comparison.

When a third-party portal site allows manufacturers to attach the "CompareMe" button at the request of a challenger, this can provide the opportunity of *active comparison* (in contrast with traditional *passive comparison* in tables) and *just-in-time advertising* that would not be possible in physical marketplaces. The "CompareThem" button may be browsed at the manufacturer's own site to enable a comparison that demonstrates the superiority of the manufacturer's products without visiting other sites. Nevertheless, it is the customer who ultimately decides whether to click the CompareMe button for comparison or not.

The comparison challenge can be found in real-world sites such as General Motors' BuyPower site, shown in Fig. 2, which compares GM's model with other vehicles [12]. Lee and Lee [8,9] developed a prototype system of CompareMe at http://compareme.kut.ac.kr (see Fig. 1), and were awarded a patent for the comparison challenge approach. No commercial sites provide the comparison challenge services yet.

The remaining part of this paper is organized as follows. The relevant literature on Internet advertising, comparative advertising, and the importance of considering brand power and trust are reviewed in Section 2. To develop a framework of advertising by the comparison challenge approach, we analyze 12 factors that determine the characteristics of comparison. To measure the value of online comparison from the challenging manufacturer's point of view, we define comparison as valuable if the comparison provides relevant, advantageous, and trustworthy information at the right level of detail. This issue is analyzed in Section 3, and demonstrated with real-world data for PC selection in Section 4.

When a manufacturer has a small number of products to submit for challenges and the competitors have a small number of models to challenge, the planning for the comparison challenge is relatively straightforward. The manufacturer may simply find the comparison sites that provide such challenges. However, when the numbers are large, it is a non-trivial problem for a manufacturer to select its own and the competitors' items to challenge and determine appropriate comparison sites. To assist this comparison




**Search result with directory name of 'Computer' and product name of 'Desktop'(Total 85items),**

[ Best price order ] [ Maker order ] [ Associated mall order ]

| Product Name | | Maker | Model | Associated Mall | Best price |
|---|---|---|---|---|---|
| Gateway 700XL | | Gateway | 700XL | Gateway Online | $ 2999 |
| Hewlett-Packard vectra vl420 | CompareGateway | Hewlett-Packard | vectra vl420 | Hewlett-Packard Online | $ 2816 |
| Gateway 500XL | CompareThem | Gateway | 500XL | Gateway Online | $ 2599 |
| IBM Xseries-lcd172 | | IBM | Xseries-lcd172 | IBM Online | $ 2499 |
| Hewlett-Packard 790n | CompareMe | Hewlett-Packard | 790n | Hewlett-Packard Online | $ 2279 |
| Hewlett-Packard e-pc42 | CompareGateway | Hewlett-Packard | e-pc42 | Hewlett-Packard Online | $ 2269 |
| IBM Xseries-lcd17 | | IBM | Xseries-lcd17 | IBM Online | $ 2199 |
| Compaq presario 8000 | CompareGateway | Compaq | presario 8000 | Compaq Online | $ 2196 |
| Dell Dim 8200 | CompareMe | Dell | Dim 8200 | Dell Online | $ 2049 |

Fig. 1. CompareMe buttons in a comparison portal.


Fig. 2. An example of CompareThem: GM's GMBuyPower.com.

challenge planning, we propose a mathematical programming model in Section 5 that maximizes the value of comparison under the constraints of comparison opportunity and budget. The performance of this model is experimentally tested using 85 models of desktop PCs manufactured by Dell, HP, Compaq, Gateway, and IBM in Section 6, and contrasted with the random banner approach and similarity-based comparison approach.

## 2. Literature review

This section reviews the literature relevant to the comparison challenge. Two relevant topics selected are Internet advertising and comparative advertising.

### 2.1. Internet advertising

#### 2.1.1. Ad formats

Banner advertising has been the simplest and most popular method of Internet advertising. The banner may be displayed arbitrarily, regardless of the contents of the web page. Internet advertising formats have continuously diversified from banner advertising to keyword search ads, classifieds, and rich media ads [5]. The Interactive Advertising Bureau [3] reported that keyword search ads led the revenues in 2004, accounting for 40% and totaling over $9.6 billion. Banner ads accounted for 19% of the 2004 revenues.

Kerner [13] argues that the benefits of online advertising are the ability to complement and enhance the use of traditional media, the ability to deliver a return on investment, more precise targeting of a fragmented audience, and providing new online ad formats that grab attention and break through clutter. According to a survey by Schlosser et al. [14] about the Internet user's attitude toward Internet advertising, Internet users enjoy looking at Internet advertisements, and appreciate their informativeness and utility for making purchasing decisions.

#### 2.1.2. Personalized Ad

To make the random banner more effective, banners are personalized to be relevant to what customers are searching for on the Internet [15]. The associative rule and collaborative filtering techniques are useful in identifying the degrees of relevance to the subjects [16–18]. The confidence of associative rules measures the likelihood that a customer who buys an item $A$ will also buy another item $B$ [19]. Kim et al. [20] have adopted the decision-tree induction technique to provide personalized advertisements in Internet storefronts, and Chickering and Heckerman [21], Bhatnagar and Papatla [22], and Gallgher and Parsons [15] proposed various frameworks for targeting banner advertising on the Internet. To investigate the reaction of customers based on their characteristics, Gallgher and Parsons [15] study the effect of demographic customer profile, and Bhatnagar and Papatla [22] examine the effect of search and navigation records.

#### 2.1.3. Advertising management tools

In the operational planning of banners, banners need to be scheduled for the advertising placement space, taking into account the display order, the item to display, and the number of times the advertisement will be placed. Mathematical models are adopted to schedule the ads and maximize the publisher's revenue under the advertisement space and time constraints [23,21,24,25]. Considering the customer's buying activities, Dologite et al. [26] design a knowledge-based system to assist in product position advertising strategy formulation. Siew and Yi [27] devise a type of agent-mediated Internet advertising, and Yager

[28] adopts intelligent agents to help with Internet advertising decisions.

### 2.2. Comparative advertising

#### 2.2.1. Comparative advertising in the non-Internet environment

In the marketing research area, comparative ads are defined as *explicit or implicit comparisons drawn between the advertised brand and its competitors* [29]. A comparative ad compares at least two brands in the same generic product/service class on specific product/service attributes. In 1971, the Federal Trade Commission (FTC) of United States began encouraging television networks to broadcast ads with comparative claims to provide more information for purchase decisions. Comparative advertising is used quite often in the US and comprises a significantly higher proportion of advertisements than in the member states of the EU and Korea [30,31].

The purpose of comparative advertising can be divided into two categories: *comparative association advertising*, which shows the similarity between the two brands, and *comparative differentiation advertising*, which differentiates by demonstrating the superiority of the advertised brand [32]. Grewal et al. [29] found that consumers perceive similarities between the advertised and compared brands, even when the comparative advertisement intends to differentiate the brand on one or multiple attributes. They also found that a comparative ad is more effective than a non-comparative ad in creating attention and enhancing message and brand awareness, the level of message processing, favorable brand attitudes, and purchase intentions and purchase behaviors. Thompson and Hamilton [33] explained that comparative ads are more effective than non-comparative ads when consumers use analytical processing, but that the converse is true when consumers use imagery processing. Thus, when the advertising format is compatible with the consumers' mode of processing, their ability to process information is enhanced.

Donthu [34] studied the effect of advertising intensity, and found that the more the intensity of comparative advertising increased, the more consumers' recall increased. He also found that intense comparative advertisements were created by explicitly naming the product's competing brands, making only positive comparisons, making attribute level comparisons that emphasize salience, and spending most of the ad time on making comparisons. These studies, however, were conducted only in the non-Internet context.

#### 2.2.2. Table comparison on the Internet

On the Internet, the tabular comparison is a very popular method of comparison, and provides a very precise and detailed comparison at a cheaper price than other mass media like television. This has made it easier to compare a vast number of items in detail. The tabular comparison, as illustrated in Fig. 3, contrasts the specifications and prices of comparable items, usually with additional multimedia images [35,36]. To be included in the comparison, manufacturers register their products at a comparison portal site, and may pay a fee based on the cost per 1000 impressions (CPM), click-through rate, and click-and-buy ratio, which is also called a conversion rate [5].

Among the many models displayed, customers select those in which they are particularly interested for a detailed comparison. In this regard, the role of the manufacturer is passive. To complement the passive comparison, we propose the comparison challenge approach, described in the next sections, to allow the manufacturers to initiate more active comparisons.

#### 2.2.3. Impact of trust and brand

In any comparison, the trustworthiness of manufacturers and advertisement contents is very important in

| Manufacturer | Dell | Gateway |
|---|---|---|
| Model | Dim 8200 | 700X |
| Price | $ 2049 | $ 1999 |
| CPU | P4 2.53 Ghz | P4 2.26 Ghz |
| Memory(RAM) | 512MB PC800 RDRAM | 512M PC800 RDRAM |
| Hard Disk Drive(HDD) | 80GB UATA100 | 120GB UATA100 7200 |
| Monitor | 19 CRT | 17 LCD |
| CD/DVD ROM Drive | 16x DVD | 48x DVD 40x12x48 CDRW |
| Video Adapter | 64MB DDR nvidia Geforce3 Ti 200 | 64M nvidia Geforce2 MX400 AGP |
| Sound Adapter | SB Live Digital | SB Audiligy |
| Network Adapter | 56k Telephony modem | 56k PCI, Adapter |
| Bundled Software | MS worksuite 2002, money2002 | MS Work Suite 2002, Word, Encarta |
| Operating System | Windows XP HE | Windows XP HE |
| Limited Warranty and Support | 1 year | 1 year |

Fig. 3. An illustrative tabular comparison.

attracting the customer's final click and purchase. When there is no trust in the manufacturer's brand, the information that the manufacturer provides is almost useless [37–41]. Chu et al. [10] demonstrated that a well-known online retailer brand increases purchase intention for a weak manufacturer brand more than for a strong one; in contrast, a reputable infomediary increases purchase intention for a strong manufacturer brand more than for a weak one. Kim and Benbasat [11] organized the factors that influence trustworthiness into four categories: personal information, product quality and price, customer services, and store presence. Uslaner [42] discussed the influence of basic trust in the offline society on the amount of trust online. Wang et al. [43] examined the nature of consumer trust using the concept of cue-based trust, and Biswas and Biswas [44] argued that certain signals such as retailer reputations, perceived advertising expenses, and warranties are perceived as strong reducers in online shopping, to a greater extent than for in-store shopping conditions.

In the non-Internet context, Pechmann and Ratneshwar [32] and Pechmann and Stewart [45,46] studied the effect of brand in comparative ads. Pechmann and Ratneshwar [32] found that direct comparative ads are effective for both unfamiliar and familiar advertised brands when the featured attribute is typical of the category. Pechmann and Stewart [45] studied the effect of comparative advertising on attention, memory, and purchase intention. They found out that for low-share brands the direct comparative ad attracts attention and enhances purchase intentions, but for established brands detracts from purchase intentions by increasing awareness of competitors and sponsor misidentifications. Pechmann and Stewart [46] also found out that direct comparative ads were more effective than both indirect comparative ads and non-comparative ads for promoting *very low* market share brands and *very high* market share brands, but direct comparative ads featuring moderate-share or parity brands were not particularly effective.

We need to study the effect of trust and brand in the context of online comparison challenges in future research; this is not the main topic of this paper. In the meantime, we can adopt the result that Pechmann and Stewart [45] have obtained – the comparison challenge will be more effective for low-share brands. In measuring the effectiveness of a comparison, the trust and brand are important factors because they will influence customers' clicking and buying behavior.

## 3. Framework of online comparison challenge

To develop the framework of comparison challenge, we analyze 12 aspects that determine the types of comparison.

(1) *Comparison subject*. A challenging manufacturer identifies its product displayed online as the subject of comparison challenge. We denote the *comparison subject* item as $i$, $i = 1,\ldots,m$.

(2) *Comparison object*. The comparison challenger identifies the targeted item, named the *comparison object* $j$, $j = 1,\ldots,n$. The objects will be paired with the corresponding comparison subject $i$.

(3) *Comparison challenge*. A comparison challenge, denoted as $C(i,j)$, is the challenge of subject $i$ to object $j$.

(4) *Comparison universe*. The comparison universe $U$ is composed of the comparison set of products that the challenger is able to compare, and is represented as $U = [C(i,j), i = 1,\ldots,m, j = 1,\ldots,n]$. The number of challenge opportunities will be limited by the comparison universe and advertising budget.

(5) *Triggering point of comparison challenge*. The comparison challenge button may pop up when either the subject or object is displayed, as shown in Fig. 1. The challenge can be classified as *CompareMe* or *CompareThem*, depending upon where the challenge occurs. The actual comparison, as shown in Fig. 3, will be invoked when the customer clicks on either button:

- *CompareMe* indicates that the comparison subject can be triggered when the comparison object is displayed. The CompareMe strategy is useful when customers view the comparison object more often than they view the comparison subject. We denote the comparison challenge $C(i,j)$ that uses the CompareMe strategy as $\mathrm{CM}(i,j)$.
- *CompareThem* indicates that the comparison object is triggered when the comparison subject is displayed. The CompareThem strategy is useful when customers visit the comparison subject first. We denote the comparison challenge $C(i,j)$ that uses the CompareThem strategy as $\mathrm{CT}(i,j)$.

  Thus, $C(i,j) = \{\mathrm{CM}(i,j), \mathrm{CT}(i,j)\}$

(6) *Comparison mediator*. The comparison challenge may be implemented at one of the following sites: the online retailer's site, third-party comparison portal sites, and the challenging manufacturer's site. The manufacturer's site can only adopt the CompareThem strategy, while the others can adopt both CompareMe and CompareThem strategies.

(7) *Level of detail in comparisons.* The online advertising method and level of detail in comparisons are interrelated [29]. A comparison may be conducted at the level of the manufacturer name, product category, or product specification. Banner ads (both arbitrary and personalized) may be used for the brand image at the level of manufacturers and product categories. However, for ads at the product specification level, a tabular comparison is useful.

(8) *Comparison factors and functional similarity*. To select items, customers need to compare the prices, functional specifications and services. The comparison of price is straightforward because the unit is common. However, the selection of functionally similar items needs a more sophisticated measurement of similarity. In fact, most systems on current Web sites support comparison with the most similar models. In the study of case-based reasoning,

various measures of similarity are defined according to the nearest neighbor algorithm [47]. The functional similarity here, denoted by SIM($i$,$j$), can be measured by the distance between the subject item $i$ and object item $j$ as stated in Eq. (1). A positive value of SIM($i$,$j$) implies that the overall function of subject item $i$ outperforms the object item $j$:

$$\mathrm{SIM}(i,j) = 1 - \sum_k w_k \cdot (f_{ik} - f_{jk}) \Big/ \sum_k w_k \tag{1}$$

where $k$: index of $k$th functional factor, $f_{ik}$: normalized value of the $k$th functional factor of subject item $i$, $f_{jk}$: normalized value of the $k$th functional factor of object item $j$, $w_k$: the weight of factor $k$.

The values of functional factors are normalized to be $0 \leqslant f_{ik}, f_{jk} \leqslant 1$ for all $i,j,k$, and the larger value implies higher performance. To quantify the functionality of numeric and non-numeric factors, we have used the thesaurus of values developed for the PC domain that was developed by another project [48]. Sites like http://www.CPUScoreCard.com also provide the quantified performance value of certain products. If such measures are available publicly, we can adopt those values first.

For the numeric measures, we normalize the functional value by dividing the original measure by a common denominator. For instance, the memory size is measured in mega-bytes (MB), and the minimum and maximum in the comparison universe are 64MB and 1024MB. Since the minimum in this case is not far from zero, we regard the lower bound as zero. The upper bound is 1024. So the normalized scale of an example memory size of 512MB can be computed as $(512-0)/(1024-0) = 0.5$. The treatment of non-numeric measures is more difficult, as there is no single measurement method that can satisfy all situations. In this study, we adopt the relative performance order as the measure, and the order value is transformed to the scale $[0,1]$. With normalized scales, the heterogeneous measures can be aggregated. Since all normalized measures stay in $[0,1]$, the distance also stays in $[0,1]$: thus, $0 \leqslant f_{ik} - f_{jk} \leqslant 1$ and $0 \leqslant \mathrm{SIM}(i,j) \leqslant 1$.

The functional gap may be converted to a monetary value by counting the cost of components that is necessary to fill the gap. The cost of components can be derived from the sites such as http://www.pricewatch.com and http://www.streetprices.com.

(9) *Value of comparison.* The value of comparison can be defined as the *superior price and functions, which a customer can discover by comparing the price and functions*. The value of comparing a subject item $i$ with object item $j$, $v_{ij}$ can be denoted as $v_{ij} = \mathscr{V}[(f_{ik} - f_{jk})\ \forall_k,\ (P_i - P_j)]$, where the parameters $P_i$ and $P_j$ denote the normalized price in $[0,1]$ of item $i$ and $j$, respectively. The value function $\mathscr{V}$ here is similar to the notion of utility function in the multi-attribute decision-making model [49]. To derive a composite value from the multiple factors, we adopt a linear weighted sum model in Eq. (2) as a surrogate of the utility function:

$$v_{ij} = r\left[\sum_k w_k \cdot (f_{ik} - f_{jk}) \Big/ \sum_k w_k\right] + (1-r)[P_j - P_i] \tag{2}$$

$$0 \leqslant \sum_k w_k \cdot (f_{ik} - f_{jk}) \Big/ \sum_k w_k \leqslant 1 \tag{3}$$

where $r$: weight between the performance and price, $0 \leqslant r \leqslant 1$.

The $v_{ij}$ can also be derived from the similarity as

$$v_{ij} = r[1 - \mathrm{SIM}(i,j)] + (1-r)[P_j - P_i] \tag{4}$$

Theoretically, the weights $w_k$ and $r$ should be derived from each individual customer. When the gap of performance can be filled by recruiting the necessary components, as is the case in the PC domain, the performance gap can be commensurable with price gap, and be summed together as (2).

(10) *Advantageous regions of comparison*. For a comparison challenge, a subject item should surpass the object items being compared in either price or performance, or both. From the challenger's point of view, there is no incentive in challenging for the comparison of dominated items. The dominance of price and performance is illustrated in Fig. 4 for the cases of 85 desktop computers manufactured by Dell, Gateway, HP, Compaq, and IBM as of 2002.

For a particular subject $i$, the objects can be classified into four regions:

- In Region I, the subject is superior to the object in both price and performance. The subject has an absolute competing power.
- In Region II, the performance of the subject is superior to that of the object, but the price of the subject is higher.
- In Region III, the performance of the subject is inferior to that of the object, but the price of the subject is lower.
- In Region IV, both price and performance of the subject are inferior to those of the object. Subjects in this region should not propose a comparison challenge.

The policy of selecting the comparison region may be one of the followings: Region I only; Region I and II; Region I and III; or Region I, II and III. In Region I, it is absolutely advantageous to compare, but the comparable number of objects is relatively small. Thus the total value of comparison with Region I alone is not necessarily the largest. In Section 4, we will see the sensitivity of region selection policy.

(11) *Relevance of comparison.* If a comparable object item has only few identical factors with a subject item, the comparison may be irrelevant. Accordingly, the degree of matching specifications determines the *level of relevant information*. To ensure a high level of relevance, we may restrict the scope of comparison to those products with certain common factors. For instance, desktop computers have four categories of CPU processors such as Pentium 4 1.X, Pentium 4 2.X, Pentium 4 Celeron and AMD Athlon. A customer may wish to only compare the objects that have the same processor. This category-selection rule can be applied along with the regional selection policy to make the comparison more effective.

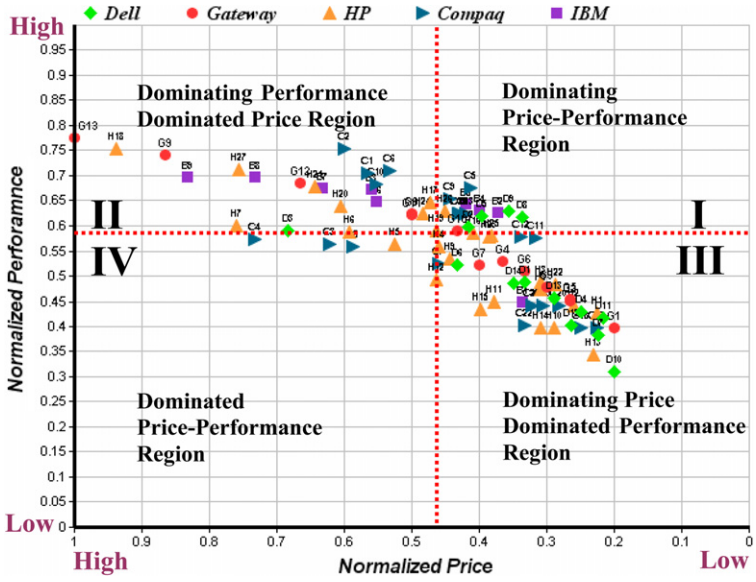



Fig. 4. An illustrative price and performance diagram.

(12) *Source of comparison information and trustworthiness.* The trustworthiness of information used for comparison is very sensitive to the customer's decision to click for a detailed comparison, as discussed in Section 2. So it is necessary to consider the effect of information sources and the manufacturer's brand on the behavior of customers' clicking the challenged comparison. Estimating the clicking-through ratio and click-and-buy ratio between competing brands is an interesting topic of research, although it is not a main topic of this paper.

The major sources of information comprise the following, and multiple sources may be used together to compile the comparison information:

- *Manufacturers' catalogs*. These catalogs are the best source for detailed specifications. The trustworthiness of this information depends on the reliability of the company itself. Third-party certification may enhance the trust of customers.
- *Competitors' catalogs*. These catalogs may be the best source for detailed specifications of rival models in a CompareThem challenge. The information should not be intentionally distorted or partially overlooked. Third-party certification will also be helpful.
- *Third-party publications*. Third-party comparison sites may confirm the actual functionality and price. However, it would be very expensive to confirm this information physically, so the information may be collected in cooperation with trustworthy consumer reports.

### 3.1. Model of a valuable comparison challenge

Based on the analyses above, we construct the model of a valuable comparison challenge: *A comparison challenge is valuable if the compared objects are relevant; the level of detail is appropriate; the comparison confirms the superiority of a subject over an object; and the information in the comparison is trustworthy.* The comparison value can be measured by the potential functional enhancement and price reduction achieved through the comparisons. The model of a valuable comparison challenge is depicted in Fig. 5. It shows five factors that determine the value of comparison challenges.

Since no commercial sites feature a Comparison Challenge yet, the empirical validation of this framework is not possible at this point. However, we can validate the framework by demonstrating it with an example case (see Section 4) and by using experimental data to analyze and compare its performance with the traditional approaches of random banner and similarity-based comparison (see Section 6).

We need to build a comparison challenge planning model that can maximize the total value of comparison within a budgetary limit for cases where a manufacturer produces multiple items and must challenge multiple competitors' items. A mathematical programming model can

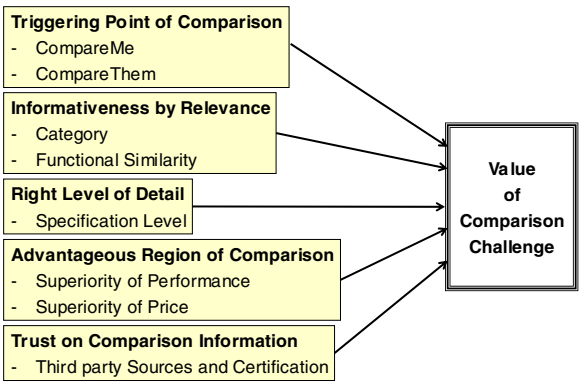



Fig. 5. Model of valuable comparison challenge.

be effectively applied for this purpose, as described in Section 5. This model can be useful not only for advertisement planning but also for strategic positioning of new products during the product development stage.

## 4. Illustration of a comparison challenge for PC selection

To apply the comparison challenge model to the advertising of PCs, we have developed a prototype of third-party comparison portal at http://compareme.kut.ac.kr. Suppose Gateway regards Dell, HP, Compaq, and IBM as its primary competitors, and challenges its competitors to a comparison. The market share of Gateway is only 7.3% [50], and based on the results of Pechmann and Stewart [45], the Comparison Challenge will be more effective for this kind of low-share company. However, its relatively lower brand power implies a relatively lower click-through-ratio even though it challenges.

In this illustration, Gateway has 13 subject items to challenge while its competitors have 72 potential comparable objects. The specifications and the alternative values are illustrated in Table 1. In this case, the comparison universe is $U = [C(i,j),\ i = 1,\ldots,13,\ j = 1,\ldots,72]$, and the possible alternatives of comparison challenges are $13 \times 72 = 936$.

Gateway can adopt both the CompareMe and CompareThem strategies as illustrated in Fig. 1. The button could be marked as "CompareMe" or "Compare Gateway." Including the challenger's name will be more informative, but many challenges may be noted as simply "CompareMe." Since the market share of Gateway is only 7.3%, we expect that more CompareMe challenges will be necessary because online exposure is approximately proportional to the market share. The other manufacturers, of course, could also register for the comparison challenge from each company's perspective. The level of detail selected for the comparison is a full specification, as illustrated in Fig. 3.

To measure the overall performance of item $I$, we adopt the weighted sum of the factors as $\sum_k w_k f_{ik}$. Conceptually, the weight should be derived from the preferences of the customer group. In this illustration, we adopt the relative cost of each factor as a surrogate of weight. To compute the value of the comparison in Eq. (2), the weights between the price and performance can be selected by customers. This illustration assumes the weights of performance and price are equal to 0.5.

Suppose a subject model is the model Gateway 300. It is superior to five competing items in both performance and price (in Region I), superior to 24 items in performance at a higher price (in Region II), and superior to 39 items in price at a lower performance (in Region III). The model is inferior to four items in both performance and price (in Region IV). Gateway may challenge the regions with the strategy of: Region I only; Regions I and II; Regions I and III; or Regions I, II and III. The selection of region really depends upon the manufacturer's marketing strategy and whether it chooses to pursue price competitiveness, performance competitiveness, or both. Since the customer's experience and level of information will influence the click-through rate in the future, challenging too many models without sufficient justifications may not necessarily be beneficial in the long run. The impact of these policies is examined experimentally in Section 6.

The challenged items can be further classified if a customer is willing to consider the categories of CPU processors: Pentium 4 1.X, Pentium 4 2.X, Pentium Celeron, and AMD Athlon. By combining the region policy and category policy for Gateway's 13 items, we can derive eight scenarios for the experiment:

[Scenario A] Compare with all items in Region I.
[Scenario B] Compare with all items in Regions I and II.
[Scenario C] Compare with all items in Regions I and III.
[Scenario D] Compare with all items in Regions I, II and III.
[Scenario A*] Compare with items in the same CPU category of Region I.

Table 1
Specifications and their values for the desktop PCs

| Specification | | Units | Value alternatives | Comments |
|---|---|---|---|---|
| CPU | Type | N/A | Pentium4, Celeron, Athlon-XP, Athlon-MP | |
| | Speed | Ghz | 2.4, 2.0, 1.9, 1.6, 1.3 | |
| RAM | Type | N/A | SDRAM, DDR-SDRAM, RDRAM | |
| | Size | MB | 1024, 512, 256, 128 | |
| HDD | Size | GB | 120, 80, 40, 20 | |
| | Speed | RPM | 7200, 5400 | Revolution per minute |
| CD/DVD | | N/A | 48× CDROM, 32 × 10 × 40 CDRW, 16× DVDROM, COMBO, etc. | Maximum transfer speed of Write–Rewrite–Read |
| Monitor | Type | N/A | LCD, CRT (standard) display | |
| | Size | In | 15″, 17″, 18.1″, 19″ | |
| Video-output | Type | N/A | Integrated, GeForce ATI | |
| | VRAM | MB | 16, 32, 64, 128, 256 | |
| Audio-output | | N/A | Integrated, SoundBlaster | |
| Network/Modem | | N/A | Integrated, 56k-modem, 10/101NIC | |
| S/W | | N/A | MS-Worksuits, Office Money | |
| OS | | N/A | WindowsXP, Windows2000, Linux | Home-Edition SME |
| Warranty | | year | 3, 1, 0.5, 0.25 | 6-months 3-months |

Table 2
Scenarios of selecting region and category

| Category | No. of possible comparison pairs | Scenario | Number of comparison pairs |
|---|---|---|---|
| Compare with all items in the region | 936 | [A] All items in Region I | 89 |
| | | [B] All items in Region I and II | 189 |
| | | [C] All items in Region I and III | 336 |
| | | [D] All items with Region I, II and III | 456 |
| Compare with items within the same CPU category | 178 | [A*] Items with the same CPU category in Region I | 24 |
| | | [B*] Items with the same CPU category in Region I and II | 52 |
| | | [C*] Items with the same CPU category in Region I and III | 91 |
| | | [D*] Items with the same CPU category in Region I, II and III | 119 |

[Scenario B*] Compare with items in the same CPU category of Regions I and II.
[Scenario C*] Compare with items in the same CPU category of Regions I and III.
[Scenario D*] Compare with items in the same CPU category of Regions I, II and III.

The number of possible comparisons for each scenario is listed in Table 2. For each scenario, we can use a mathematical programming model to compute the value of the comparison. For instance, in Scenario A*, there are only 24 possible comparison pairs although each of them is the most beneficial comparison. On the other hand, Scenario D has the largest number of comparison pairs: 456. Based on the value of comparison that can be created by the scenario, Gateway can select the best comparison challenge plan, as described in Section 6.

## 5. Comparison challenge planning model and experimental setting

Based on the comparison scenarios, we can formulate a model that can maximize the value of comparison from a challenging manufacturer's point of view. Although the concept of this model is basically similar to the media scheduling models that maximize the revenue under the space and time constraints of advertising [23–25], this model has a completely different objective function and constraints.

### 5.1. Formulation for comparison value maximization

A deterministic single period plan can be formulated as an integer programming model in Eqs. (5)–(10) below. Let us denote the notations first.

$i$ challenger's subject items, $i = 1, \ldots, 13$
$j$ competitor's object items, $j = 1, \ldots, 72$
$X_{ij}$ number of CompareMe challenges CM($i$,$j$) during the planning horizon
$Y_{ij}$ number of CompareThem challenges CT($i$,$j$) during the planning horizon
$v_{ij}$ value of challenging the comparison of subject $i$ to object $j$ defined in Eq. (2)
$V$ total value of comparison challenges $V = \sum_i \sum_j v_{ij}(X_{ij} + Y_{ij})$
$a_{ij}$ fee of challenging a comparison of subject $i$ to object $j$
$E_i$ expected number of exposures of subject $i$ during the planning horizon
$E_j$ expected number of exposures of object $j$ during the planning horizon
$B_i$ budget for subject item $i$
$B = \sum_{i=1}^{13} B_i$ total budget for a comparison challenge
$U$ universe of comparison derived by the selected scenario of region and category

$$\max V = \sum_i \sum_j v_{ij}(X_{ij} + Y_{ij}) \tag{5}$$

subject to

$$\sum_i X_{ij} \leqslant E_j \quad \forall j \tag{6}$$

$$\sum_j Y_{ij} \leqslant E_i \quad \forall i \tag{7}$$

$$\sum_i \sum_j a_{ij}(X_{ij} + Y_{ij}) \leqslant B \tag{8}$$

$$X_{ij},\ Y_{ij} \in U \tag{9}$$

$$X_{ij},\ Y_{ij}: \text{Non-negative integers} \tag{10}$$

The decision variables are $X_{ij}$ and $Y_{ij}$, the number of CompareMe and CompareThem challenges, respectively, during the planning horizon. The objective function in Eq. (5) maximizes the normalized value of comparison. The normalized value of comparison encompasses both the price and performance gaps that can be discovered through comparison. The notion of performance is basically non-monetary preference; however, in some applications the performance gap can be overcome by supplementing components, as is the case in the PC domain. In this case, the performance gap can be converted to monetary value by computing the cost necessary to fill the gap.

When the price and performance gaps are commensurable in monetary term as above, the normalized objective function value in (5) can be converted to the *monetary value of comparison* by considering the price difference and click-and-buy ratio. This is the potential value that a company can create for customers through the comparison challenges, and can also be a potential source of revenue creation.

The constraint of Eq. (6) limits the number of CompareMe challenges by the expected number of exposures to comparable objects. In the same manner, the constraint of Eq. (7) limits the number of CompareThem challenges by the expected number of subject items' exposures. The constraint in Eq. (8) is limited by the advertising budget. The constraint in Eq. (9) derives the index set depending upon the selected scenario (Region and Category) described in Section 4. The decision variables are non-negative integers owing to the restrictions of Eq. (10). To solve this integer programming model, we have used the package LINDO.

The constraints may be modified in various ways:

- If the fees for CompareMe and CompareThem are different, we need different coefficients of $a_{ij}$ for each case.
- If we need to consider multiple portal sites simultaneously, we need additional index $s$ for the site and make the decision variable $X_{ijs}$. The comparison fees $a_{ijs}$ may differ accordingly.
- The total advertising budget in (8) may be assigned to each item.
- The model may be extended to a multi-period model by adding the time index $t$ as $X_{ijt}$ and $Y_{ijt}$ and modifying the coefficients and constraints accordingly.
- When the coefficients of $w_k$ and $r$, which are necessary to derive $v_{ij}$ in (2), are probabilistic to reflect the characteristic of customer group, we may repetitively simulate the coefficients in the objective function and derive a probability distribution function of total value $V$.

### 5.2. Illustrative experimental setting

Using the optimization model in Eqs. (5)–(10), we can illustrate the effect of comparison challenges with experimental data. The planning horizon of the model is regarded as a month, and $m = 13$ and $n = 72$. The metrics on performance $f_{ik}$ and price $P_i$ are normalized to stay in $[0, 1]$. Since the maximum price of PC products was \$2999, the price is normalized by dividing it by 3000 to place its value in $[0, 1]$. Thus the normalized value can be converted back to the monetary term by multiplying it by 3000. We assume the click-and-buy rate for Gateway is 0.1%, based on the industry survey [51]. Thus the expected monetary value after click-compare-and-buy is $3V$.

The values of pairwise comparison $v_{ij}$, $i = 1, \ldots, 13$, $j = 1, \ldots, 72$ are computed by the definition in (2), and the weight of each factor $w_k$ is derived, assuming they are proportional to the additional cost of the components necessary to conduct the performance. The weight between performance and price is assumed equal, thus $r = 0.5$.

To estimate the comparison fee, we refer to the cost per 1000 exposures of a banner, which is reportedly \$3.50 [1]. By rounding the cost to 0.4 cents per exposure, the fee for a challenging exposure is regarded $a_{ij} = 0.4$ cents for all $i$ and $j$. In a real-world site, the expected number of exposures can be estimated based on the historical data. In this experiment, we arbitrarily adopt the monthly number of exposures of a sample comparison site: 422,600. To derive the experimental number of exposures for each manufacturer, the total number of exposures is divided by the manufacturer's market share, assuming the number of visits is proportional to the market share. Accordingly, the number of exposures $E_i$ and $E_j$ are derived as follows:

$$E_i = 3000 \quad i = 1, \ldots, 13$$

$$E_j = \begin{cases} 10{,}000 & \text{if } j\text{'s manufacturer is Dell}, \quad j = 1, \ldots, 14 \\ 5100 & \text{if } j\text{'s manufacturer is Compaq}, \quad j = 15, \ldots, 36 \\ 4100 & \text{if } j\text{'s manufacturer is HP}, \quad j = 37, \ldots, 63 \\ 2300 & \text{if } j\text{'s manufacturer is IBM}, \quad j = 64, \ldots, 72 \end{cases}$$

The monthly budget for a portal site is assumed to be $B = \$2000$. This implies that if Gateway proposes challenges on 10 sites in a year, the annual budget for comparison challenges is \$240,000.

## 6. Performance of the comparison challenge approach

Based on the experimental setting identified in Section 5.2, we explore the effects of eight policy scenarios described in Section 4, and contrast the performance of the comparison challenge strategy with the traditional comparison methods of random banner and similarity-based comparison.

### 6.1. Performance of comparison challenges by scenario

To see the effect of scenarios defined in Table 2, we compare the performances of eight scenarios based on the experimental setting. In this simple model, we consider one portal for a single period. The result is summarized in Table 3. The table shows the number of CompareMe challenges, the number of CompareThem challenges, the total number of exposures, the expected monetary value of comparison, the monthly advertising expense incurred for a site, and the value/expense ratio. According to the values achieved by CompareMe and CompareThem for each scenario, 69.6% of challenges on the average of all scenarios were realized by a CompareMe strategy in the Gateway case because Gateway is a low-share maker.

Among the eight scenarios, Scenario D, which includes all of the items in Regions I, II and III, can maximize the value of comparison, achieving \$61,430.61 at the advertising expense of \$1356. Fifty-eight CompareMe (out of 456 potential pairs) and 12 CompareThem (out of 456 potential pairs) comparisons contributed to the creation of this comparison value. Note that only 12.71% of possible CompareMe pairs and 2.63% of CompareThem pairs are challenged. This result shows the potential screening effect, which will reduce the customer's comparison effort. Note the manufacturer's high advertising value/expense ratio of 45.30.

On the contrary, Scenario A*, which considers items only within the same CPU in Region I, can achieve the

Table 3
Optimal comparison challenge plan by scenario

| Scenario | Number of challenges by CompareMe # of candidate | | Number of challenges by CompareThem # of candidate | | Total number of exposures | Expected monetary value of comparison [$3V$ ($)] | Ad expense [$E$ ($)] | Value/expense ratio [$3V/E$] |
|---|---|---|---|---|---|---|---|---|
| [A] All items in Region I | 26 | 89 | 11 | 89 | 170,400 | 32,032.53 | 681.6 | 47.01 |
| [B] All items in Region I and II | 35 | 189 | 12 | 189 | 240,000 | 35,375.01 | 960.0 | 36.84 |
| [C] All items in Region I and III | 57 | 336 | 12 | 336 | 329,000 | 60,125.61 | 1316.0 | 45.69 |
| [D] All items with Region I, II and III | 58 | 456 | 12 | 456 | 339,000 | 61,430.61 | 1356.0 | 45.30 |
| [A*] Items with the same CPU category in Region I | 10 | 24 | 9 | 24 | 87,700 | 20,170.17 | 350.8 | 57.51 |
| [B*] Items with the same CPU category in Region I and II | 17 | 52 | 10 | 52 | 145,000 | 23,797.62 | 580.0 | 41.04 |
| [C*] Items with the same CPU category in Region I and III | 24 | 91 | 13 | 91 | 171,200 | 36,915.63 | 684.8 | 53.91 |
| [D*] Items with the same CPU category in Region I, II and III | 25 | 119 | 12 | 119 | 181,200 | 38,220.63 | 724.8 | 52.74 |
| Average | | | | – | | 38,508.48 | 831.8 | 47.52 |

lowest comparison value of $20,170.17 at the advertising expense of $350.80 because there are only 24 candidate pairs to consider. Ten CompareMe (41.67% out of 24 potential pairs) and 9 CompareThem (37.50% out of 24 potential pairs) comparisons contribute to the creation of the comparison value. Since the region and category are already very strictly selected, a higher percentage of potential pairs is challenged. However, if we compare the percentage to the potential pairs of Scenario D (456), the percentage is merely 2.19% and 1.97% respectively. This policy thus can further reduce the customer's comparison effort, giving higher confidence to the customers who have tried the Comparison Challenge buttons. Note that the advertising value/expense ratio in Scenario A* is highest (57.51); thus when there is a strict budget, the A* policy can be an effective policy.

As mentioned earlier, the policy with the maximum comparison value in a period is not necessarily the best policy in the long run, as the screening effect and the learning effect in which experienced customers discover value will influence the click-and-buy rate in the future. Empirical study of customer behavior in this regard will be a very interesting research topic. Nevertheless, contrasting the potential value of comparisons created by each policy provides important information to balance the long-term perspective and short-term revenue. If Gateway wants to pursue the low price policy with similar functions, Scenario C may be pursued strategically.

The corporate annual value of comparison challenge can be estimated by multiplying the above values by 12 and the number of portals that will be applied. Suppose Gateway will use 10 comparison portal sites. Then the annual value of comparison challenge using Scenario D will become $61{,}430.61 * 12 * 10 = \$7{,}371{,}673$ at the advertising expense of $162,720. The potential value for the whole industry could be enormous.

### 6.2. Performance of comparison challenges according to different strategies

To validate the adequacy of the comparison value maximization model, its performance is contrasted with two other strategies: *the random challenge* and *the most similar challenge*. The random challenge strategy implies that the comparing subjects and objects are randomly selected, with an effect similar to the random banner advertisement within the same domain. The most similar challenge strategy compares the subjects with the most similar objects. This strategy is virtually the same as displaying the items similar to the customer's requirements in comparison portal sites. In the optimization model, the most similar challenge approach would solve the model in Eqs. (6)–(10) with the objective function in (11). In the objective function, the coefficient $v_{ij}$ in Eq. (4) is replaced with SIM($i$,$j$):

$$\max \sum_i \sum_j \mathrm{SIM}(i,j) \cdot (X_{ij} + Y_{ij}) \tag{11}$$

The solutions $X_{ij}$ and $Y_{ij}$ from this model are applied to Eq. (4) to compute the corresponding value of comparison. The results of normalized value with the assumption of equal click-and-buy ratio are contrasted in Table 4. The values can be converted to monetary values in Table 3 by multiplying them by 3. However, the random challenge will intuitively have a lower click-and-buy ratio.

On average, the comparison value maximization approach achieves a value of 12,836, while the random challenge approach achieves 2700.49 and the most similar challenge approach achieves 4638.09. The effectiveness of the comparison value approach is 4.75 times (12,836.16/2700.49) that of the random challenge approach, and 2.77 times (12,836.16/4638.09) that of the most similar challenge. This result implies that the comparison challenge approach significantly outperforms the random banner and

Table 4
Value of comparison by strategies

| Scenario | Strategies | | | | |
|---|---|---|---|---|---|
| | (*M*) Maximize the comparison value | (*R*) Random challenge | *R*/*M* (%) | (*S*) The most similar challenge | *S*/*M* (%) |
| [A] All items in Region I | 10,677.51 | 742.5 | 7.0 | 6648.97 | 62.3 |
| [B] All items in Region I and II | 11,791.67 | 1636.6 | 13.9 | 3097.10 | 26.3 |
| [C] All items in Region I and III | 20,041.87 | 7464.3 | 37.2 | 7883.21 | 39.3 |
| [D] All items with Region I, II and III | 20,476.87 | 8527.2 | 41.6 | 4151.54 | 20.3 |
| [A*] Items with the same CPU category in Region I | 6723.39 | 187.2 | 2.8 | 4196.73 | 62.4 |
| [B*] Items with the same CPU category in Region I and II | 7932.54 | 396.7 | 5.0 | 2911.34 | 36.7 |
| [C*] Items with the same CPU category in Region I and III | 12,305.21 | 1234.2 | 10.0 | 4875.50 | 39.6 |
| [D*] Items with the same CPU category in Region I, II and III | 12,740.21 | 1415.2 | 11.1 | 3340.29 | 26.2 |
| Average | 12,836.16 | 2700.49 | 16.1 | 4638.09 | 39.1 |

similarity-based tabular comparison. The effectiveness of the maximizing the comparison value over the random comparison escalates the most in Region I (see Scenarios A and A*). The effectiveness of random comparison is as low as 7.0% and 2.8% respectively. However, the most similar challenge performs at the 62% level in Region I because the comparison pairs in Region I were quite well filtered by the similarity rule. However, in Scenario D, the comparison value strategy effect is diminished because it considers both the Regions II and III as well, and the scenario comes close to considering all regions.

## 7. Conclusion and discussion

The types of Internet advertisements are analyzed and the comparison challenge approach is proposed as a new way of manufacturer challenged, just-in-time advertising. To develop the framework of the comparison challenge, we analyzed 12 factors that determine the taxonomy of comparison and propose a framework for the valuable comparison challenge. The framework regards a comparison challenge as valuable if the compared objects are relevant; the level of detail is appropriate; the comparison confirms the superiority of a subject over an object; and the information in the comparison is trustworthy. We proposed the CompareMe and CompareThem strategies depending upon the triggering point of comparison challenges, and classified the compared objects in terms of price and performance dominance as well as the category of salient factor such as CPU in the PC domain. The value of the comparison is defined as the difference in price and performance between a challenger's subject product and the compared objects. The idea is demonstrated in the PC domain with examples from five leading manufacturers.

To assist the planning of a comparison challenge, a mathematical programming model was formulated to maximize the comparison value under the constraints of the comparison opportunity and budget. The model was applied to eight scenarios in terms of the range of comparing objects. The model used a real-world example of PCs, with the performances of different companies' policies contrasted with one another. The comparison value is maximized in the region in which items outperform others either in price or performance, providing more comparison opportunity. However, the advertising value/expense ratio could be maximized with the items that outperform both in price and function. We demonstrated with an experimental data set that the comparison value maximization model can significantly enhance the value of comparison in contrast to the random banner and simple similarity-based comparison.

The limitations of this research provide good opportunities for follow-on research topics. For the experiment, we could not empirically collect real-world data because, at this early stage of research, no commercial comparison portal site implements the comparison challenge approach yet. Empirical studies on the impact of the comparison challenge approach on the click-and-buy ratio are important because the screening effect and the learning effect in which experienced customers discover comparison value will influence the click-and-buy rate in the future. The effect of brand on the click-and-buy ratio in the comparison shopping context will be a very interesting research issue as well. Overall, the customer behavior in terms of clicking the comparison challenges is another topic to be investigated in the next stage of research.

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