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76. Pricing Web Advertisement: Display Ads V.S. Contextual Ads

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Abstract

Most web sites provide display advertising and contextual advertising services simultaneously, which are the main ad formats in Internet. With multimedia format, the pricing of display ads is generally based on the occurrence of ad impressions. However, targeting their customers more accurately, contextual ads are performance based advertisements and are charged only if one visitor clicks a client's appointed ad. In this paper, we develop an economic model to examine the pricing strategy, profitability, and social efficiency of these two heterogeneous web advertising channels, with respect to different market structures.

Keywords: Web advertisement, Display ads, Contextual ads, Competition, Pricing Strategies

Introduction

The role of advertising is to deliver the message of individual products to consumers (Soberman 2004). Firms pursue higher exposure for products because it impresses more of the potential market; thus, motivates consumers to purchase the products. According to "Internet Advertising Revenue Report" announced by IAB in 2006 April, Internet ad revenue in the United States amounted over \$12.5 billion for the full year 2005, up from \$9.6 billion reported in 2004. The increasing number suggests that Internet is one of most fundamental brand-building components in marketing channels. The Internet ad formats can be divided into search, display-related advertising, and classifieds based on revenues ranked from high to low, accounting for more than 90 percent of revenues during these two years (http://www.iab.net/resources/ad_revenue.asp). Besides playing the role of content providers attracting different types of users, web sites may carry multimedia advertising to offer clients more ways to reach their target audience and specific marketing objectives.

Traditional ad pricing strategy used in newspaper, radio, and television is based on cost per thousand, abbreviated as CPT, which means the cost for showing the ad to one thousand viewers. Web sites may guarantee an advertiser the lowest number of impressions, an ambiguous term stamped on everyone's mind; however, nobody can show whether it is worth the price to pay for the number of times that web ads are seen by visitors. This question stems from the theatrical difference between pushing and pulling. Unlike traditional media pushing messages to individuals alternately in everyday life, people are active in Internet and pull information through this new medium, which means that audience have ability to read preferred content and avert their eyes from ad trap set by advertisers (Schwartz 1997). Consequently, click-thru rate (CTR), derived from dividing the number of visitors who clicked on an ad embedded in a web page by the number of times that the web page was delivered, becomes an index for measuring the performance of advertisement. For example, Procter & Gamble, one of biggest advertisers in American, was the first company to contract with Yahoo to pay ad fee grounded on CTR in 1996. Since click behavior is useful to demonstrate online advertising effectiveness, the first attempt for modeling such effects over

a relatively short period of time had been proposed by Chatterjee et al., which highlights the importance of explicit consumer identification procedures to enhance the value of clickstream data (Chatterjee et al. 2003).

Therefore, a new ad pricing mechanism plus contextual advertising has turned into the focus of attention because of a highly cost-effective feature. The rule is simple: clients set their bid for each placement on sections or specific pages and only pay for a qualified click when a visitor clicks on their ads. In other words, clients can pay for performance and find their most valuable targets interested in a specific type of content web sites offer. For each web page such program often represents three to five different ads in a frame, each including title, description, and display URL, whose size often corresponds to a large rectangle affording to place an independent display ad. The order of placement is determined by specific rules based on a combination of factors, such as relevancy, bid amount, click-thru rate, and so on. Therefore, customers have no ability to know when their ads appear on appointed web pages, but know that the chance of exposure is influenced by these factors. Consequently, if time pressure caused by these factors is low or moderate, this seems a reasonable and economic way for advertisers to control their budget and implement their marketing plan in Internet. Because the expense to establish and maintain an online auction-based and pay-per-click platform is respectable, most web sites cooperate with other firms which concentrate on search techniques to reduce their cost and take their profits from each page in pre-agreed proportions. The web sites just copy and paste a block of JavaScript codes to their web page and then content-related ads start working without maintaining advertiser relationships.

Literature Review

The effect advertising is mainly determined by ad expenditure level, time in market, number of competitors, and order of entry (Vakratsas et al. 2004). To expand the entire market and win market share, Bass et al. (2005) define advertising as “generic advertising” and “brand advertising” according to the effect of advertising, respectively. Their results suggest that generic and brand advertising must be properly coordinated for preventing suboptimal allocation of advertising budget. Jedidi et al. (1999) measure the effects of changes in advertising and promotion policies on sales and profits, suggesting that advertising has a positive effect on “brand equity” in the long term. Prior research suggests developing one common Web advertisement for all users may not be the most effective way to drive intended visitors to a certain web site (Korgaonkar and Wolin 2002). One of the fundamental questions that marketers face in advertisement is how to implement target advertising to specific consumers and how to allocate their media budgets (Iyer et al. 2005). In the recent studies, Kim et al. (2001) use tree induction techniques and data-mining tools to generate marketing rules that match customer demographics, providing personalized advertisement selection when a customer visits an Internet store.

Model

We consider an ad pricing problem where clients (ads sponsors) want to publish their advertising on web sites through two different channels: display advertising channel or contextual advertising channel. A purchase action is executed by a client and each client buys an ad, which could be either advertising executed in the display ads channel or contextual ads channel. Thus, we denote the total ads purchase amount during a certain time interval in this market is η_0 . Also, we divide η_0 into η_d and η_s , which represent the purchase amount with respect to display advertising and contextual advertising, respectively. The advertising fees of display advertising are charged on an impression basis; that is, no matter

whether a visitor clicks client's ad, the system charges p_d for impression as long as the web page containing client's ad is delivered to visitor's browser. On the contrary, the advertising fees of contextual advertising are charged on a click basis; that is, no matter whether a visitor views client's ad, the system can't charge any fee until someone clicks clients' ads. The price of one click is denoted as p_s . Notice that though both display and contextual ads could be delivered in the same website, these two heterogeneous advertising platforms may be operated a single (monopolistic) web advertising channel firm or two competitive firms.

There are two main types of effect (benefit) caused by web ads: *impression* benefit and *click* benefit. Impression benefit catches the value of impressing the visitors about the advertised products or the firm, even without any further business transactions. However, click benefit mainly considers the value developed when visitors click a specific ad to an appointed web site. Thus, click benefit is measured based on revenue generating from further business transactions, whereas impression benefit is associated with value from brand building. Display advertising is presented in multimedia format, whereas contextual advertising are presented as text only. Thus, display ads delivery better performance in delivering the impression benefit. We assume, the impression effect is heterogeneous to different clients; therefore, we let the impact factor of impression effect θ_i of the clients be uniformly distributed within a unit interval. A client i with higher θ_i has higher intention to build brand loyalty. We denote $\beta_d(\gamma_d)$ and $\beta_s(\gamma_s)$ as impression benefit (click thru rate) with respect to display advertising and contextual advertising, respectively. Also, we denote the value from the outcome of a click as α . Therefore, each client choosing display advertising can receive benefit from an impression; however, the expected benefit of clicking effect she receives is $\alpha\gamma_d$ because the probability of a click event occurring in display advertising channel is γ_d . Similarly, each client choosing contextual advertising can receive benefit from an ad click; however, the expected benefit of branding effect she receives is β_s/γ_s because her ad might had been delivered several times before her ads is clicked by someone.

Furthermore, because of the limited capacity of the advertising platform, we should consider queuing effect. As the advertising platform is shared by all the subscribed ads, ad sponsors must wait until the ad activity is committed (e.g. an impression for display advertising and a click for contextual advertising). The cost of average waiting time of display advertising and contextual advertising are denoted as $w_d\eta_d$ and $w_s\eta_s$, respectively. The waiting time increases as the number of clients in channels (η_d and η_s). An advertising supplier who provides display advertising platform can reduce waiting time by aggregating more web sites to obtain sufficient traffic volume (w_d becomes smaller). Similarly, the waiting time of contextual advertising can also be reduced by high traffic volume; moreover, the accuracy of search results will help "consume" clients' ads (w_s becomes smaller). In other words, the quality of search engine is also a key factor to reduce time cost for clients in contextual advertising channel. Thus, the payoff of a typical client i is given by

$$\Pi_i = \begin{cases} \alpha\gamma_d + \beta_d\theta_i - w_d\eta_d - p_d & \text{display ads (an impression)} \\ \alpha + (\beta_s/\gamma_s)\theta_i - w_s\eta_s - p_s & \text{contextual ads (a click)} \end{cases} \quad (3.1)$$

Since multimedia appeals to a variety of visitors than text does, it is natural that $\beta_d > \beta_s$ should be a common perspective. For the purpose of exposition, we assume β_s as zero; thus, β_d can be interpreted as the comparative impression benefit from ads with

multimedia display. The payoff of a typical client i is rewritten as

$$\Pi_i = \begin{cases} \alpha\gamma_d + \beta_d\theta_i - w_d\eta_d - p_d & \text{display ads (an impression)} \\ \alpha - w_s\eta_s - p_s & \text{contextual ads (a click)} \end{cases} \quad (3.2)$$

Besides, we assume impression and click effects are sufficiently high ($\beta_d > \alpha > w_s\eta_0$) such that each client will purchase an ad no matter which ad type she purchase. Since each client chooses a preferable ad service from display advertising and contextual advertising, the market-segmentation condition is given by

$$\alpha\gamma_d + \beta_d\hat{\theta} - w_d\eta_d - p_d = \alpha - w_s\eta_s - p_s,$$

where the payoff a client with type $\hat{\theta}$ receives is indifferent between these two ad services.

$$\hat{\theta} = \frac{\alpha(1-\gamma_d) + (p_d - p_s) + (w_d\eta_d - w_s\eta_s)}{\beta_d}. \quad (3.3)$$

All clients indexed by $\theta_i \in [0, \hat{\theta}]$ choose contextual advertising and the other clients indexed by $\theta_i \in [\hat{\theta}, 1]$ prefer display advertising. Furthermore, $\hat{\theta}$ reveals that display advertising can increase its market share by making a strong impression on visitors or enhancing click thru rate; likewise, contextual advertising can increase its market share by enhancing the quality of search engine so as to reduce waiting time as well as raise click thru rate. In other words, contextual advertising will occupy the prevailing position if search engine can match ads to the content of web sites precisely. Consequently, according to conditions $\eta_s = \eta_0\hat{\theta}$ and $\eta_0 = \eta_s + \eta_d$, the demand functions of multimedia advertising and contextual advertising are written as

$$\eta_d = \frac{\beta_d + w_s\eta_0 - \alpha(1-\gamma_d) - \Delta p}{\beta_d/\eta_0 + w_s + w_d} \text{ and } \eta_s = \frac{w_d\eta_0 + \alpha(1-\gamma_d) + \Delta p}{\beta_d/\eta_0 + w_s + w_d}. \quad (3.4)$$

Pricing in the Web Advertisement Markets

We first examine the pricing strategy of a monopolized advertising channel firm which provides display advertising and contextual advertising simultaneously, or offer a pure ad service. Subsequently, we consider the case that in this market there exist two leader advertising firms which own different competitive advantage. For example, Quigo is a well-known web advertising firm, concentrating on content-targeted product. On the contrary, e-marcom is an innovative marketing company that provides interactive multimedia advertising to help their customers increase sales and improve branding effectiveness.

Monopolized Advertising Firm in the Market

Since fixed cost is irrelevant to firm's final decision on postal prices, we only consider marginal cost of display advertising and contextual advertising, denoted as c_d and c_s ; thus, the profit-maximization problem of monopolized ad firm is given by

$$\text{Max}_{p_d^m, p_s^m} \pi^m = (p_d^m - c_d)\eta_d^m + (p_s^m - c_s)\eta_s^m \quad (4.1)$$

The marginal cost of display advertising is dominated by multimedia design cost and higher transmission cost due to larger file size. On the contrary, the marginal cost of contextual advertising is slight because text-only format can saves designing cost and reduce traffic; here, with the loss of generality, we assume c_s as zero to simplify the profit-maximization problem. Since both the demand functions of display advertising and contextual advertising are associated with the relative price of these two services $\Delta p = p_d^m - p_s^m$, instead of solving

the first order condition with respect to p_d^m and p_s^m , we rewrite the objective function as

$$\text{Max}_{p_s^m, \Delta p} \pi^m = \frac{1}{\beta_d/\eta_0 + w_s + w_d} \left\{ (p_s^m + \Delta p - c_d)(\beta_d + w_s \eta_0 - \alpha(1 - \gamma_d) - \Delta p) + p_s^m (w_d \eta_0 + \alpha(1 - \gamma_d) + \Delta p) \right\} \quad (4.2)$$

It can be easily observed that the joint profit is linearly increasing with p_s^m , and π^m is concave on Δp . Solving first order condition $\partial \pi^m / \partial \Delta p = 0$, we find the optimal price offset $\Delta p^m = (\beta_d + w_s \eta_0 - \alpha(1 - \gamma_d) + c_d) / 2$. Then, the unit price of contextual advertising should be as high as possible such that the profit is maximized. It can be set to be a value satisfying the equation $\alpha - w_s \eta_s^m - p_s^m \geq 0$. Hence, the demand functions in this hybrid service are given by

$$p_s^m = \alpha - w_s \left(\frac{\beta_d + w_s \eta_0 + 2w_d \eta_0 + \alpha(1 - \gamma_d) + c_d}{2(\beta_d/\eta_0 + w_s + w_d)} \right), p_d^m = p_s^m + \Delta p^m, \quad (4.3)$$

$$\eta_d^m = \frac{\beta_d + w_s \eta_0 - \alpha(1 - \gamma_d) - c_d}{2(\beta_d/\eta_0 + w_s + w_d)}, \text{ and } \eta_s^m = \frac{\beta_d + w_s \eta_0 + 2w_d \eta_0 + \alpha(1 - \gamma_d) + c_d}{2(\beta_d/\eta_0 + w_s + w_d)}. \quad (4.4)$$

Obviously, providing hybrid advertising in web site is always better than either pure display advertising or contextual advertising platform as a pure advertising approach becomes a special case of a hybrid approach in which one of service is closed.

Proposition 1 (A Monopolistic Web Advertisement Market)

- (a) Contextual ads channel is always offered, while display ads channel is offered when click through rate is sufficiently large such that $\gamma_d > \hat{\gamma}_d = 1 - (\beta_d + w_s \eta_0 - c_d) / \alpha$.
- (b) The price of the display ads (an impression) is greater than the price of the contextual ads (a click) if display ads channel is offered. In addition, the demand of contextual ads is higher than that of display ads. Formally, $\Delta p^m > 0$ and $\eta_d^m < \eta_s^m$.

Dual Advertising Firms in the Market

Let us consider a simultaneous price competition between multimedia advertising and contextual advertising. π_d^c (π_s^c) and p_d^c (p_s^c) are denoted as the profit function and the price of multimedia advertising (contextual advertising), respectively. The profit functions are given by

$$\pi_d^c = (p_d^c - c_d) \frac{\beta_d + w_s \eta_0 - \alpha(1 - \gamma_d) - \Delta p}{\beta_d/\eta_0 + w_s + w_d}, \pi_s^c = p_s^c \frac{w_d \eta_0 + \alpha(1 - \gamma_d) + \Delta p}{\beta_d/\eta_0 + w_s + w_d}. \quad (4.4)$$

From first order conditions, $\partial \pi_d^c / \partial p_d^c = 0$ and $\partial \pi_s^c / \partial p_s^c = 0$, we derive the price response functions of these two services, which are given by

$$p_d^c(p_s^c) = \frac{p_s^c + \beta_d + w_s \eta_0 - \alpha(1 - \gamma_d) + c_d}{2} \text{ and } p_s^c(p_d^c) = \frac{w_d \eta_0 + \alpha(1 - \gamma_d) + p_d^c}{2}. \quad (4.5)$$

Solving both equations simultaneously, we have Nash equilibrium,

$$p_d^c = \frac{w_d \eta_0 + 2\beta_d + 2w_s \eta_0 - \alpha(1 - \gamma_d) + 2c_d}{3}, p_s^c = \frac{2w_d \eta_0 + \beta_d + w_s \eta_0 + \alpha(1 - \gamma_d) + c_d}{3}. \quad (4.6)$$

Consequently, the demand functions and the profit functions are written as,

$$\eta_d^c = \frac{2\beta_d + w_d \eta_0 + 2w_s \eta_0 - \alpha(1 - \gamma_d) - c_d}{3(\beta_d/\eta_0 + w_s + w_d)}, \eta_s^c = \frac{\beta_d + 2w_d \eta_0 + w_s \eta_0 + \alpha(1 - \gamma_d) + c_d}{3(\beta_d/\eta_0 + w_s + w_d)}, \quad (4.7)$$

$$\text{We have } \Delta p^c = p_d^c - p_s^c = \frac{\beta_d + (w_s - w_d)\eta_0 - 2\alpha(1 - \gamma_d) + c_d}{3}.$$

Proposition 2 (A Duopolistic Web Advertisement Market)

- (a) The higher the click thru rate of display advertising, γ_d , the more (less) expensive the display advertising (contextual advertising). Formally, $\partial p_d^c / \partial \gamma_d > 0$, and $\partial p_s^c / \partial \gamma_d < 0$.
- (b) Both prices of display and contextual ads increase as the cost of design a display ad c_d , the impression effect of display ads β_d , the market size η_0 , but decrease with the traffic of the website (smaller w_d) and the accuracy of contextual search engine (smaller w_d).
- (c) The price heterogeneity of display ads and contextual ads is smaller. Formally, $\Delta p^c < \Delta p^m$.
- (d) The demand of contextual ads (display ads) is lower (higher) in a competitive market. Formally, $\eta_s^c < \eta_s^m$ and $\eta_d^c > \eta_d^m$.

Analysis of Economic Efficiency

In this section we consider a socially planned market in which both display advertising and contextual advertising are offered. Subsequently, we compare socially optimal results with resource allocation in the monopolistic market and competitive market. The efficiency of approach allocation is measured by its social welfare, which is all sum of clients' payoffs and the advertising channel providers. In the following, we first investigate the characteristics of an efficient (or social welfare maximizing) channel allocation, which is social planner's objective for value-maximizing. The social welfare of the advertisement market is given

by $W = \sum_{i=1}^n \Pi_i + \pi_d + \pi_s$. Thus, the socially optimal choices can be found by solving optimization problem as follows:

$$\text{Max}_{\eta_d, \eta_s} W = \int_0^{\eta_s/\eta_0} \alpha - w_s \eta_s d\theta + \int_{\eta_s/\eta_0}^1 \alpha \gamma_d + \beta_d \theta - w_d \eta_d - c_d d\theta \quad \text{s.t. } \eta_d + \eta_s = \eta_0 \quad (5.1)$$

Solving these program yields the result of efficient allocation for each channel given by

$$\eta_d^w = \frac{\beta_d + 2w_s \eta_0 - \alpha(1 - \gamma_d) - c_d}{\beta_d/\eta_0 + 2w_s + 2w_d} \quad \text{and} \quad \eta_s^w = \frac{2w_d \eta_0 + \alpha(1 - \gamma_d) + c_d}{\beta_d/\eta_0 + 2w_s + 2w_d}. \quad (5.2)$$

Thus, it would be social optimal if the relative price of these two services satisfies

$$\Delta p^w = p_d^w - p_s^w = \frac{\beta_d w_d + (\beta_d/\eta_0 + w_s + w_d)c_d - (w_s + w_d)\alpha(1 - \gamma_d)}{\beta_d/\eta_0 + 2w_s + 2w_d}. \quad (5.3)$$

Proposition 3 (Efficient Market)

If the market size is sufficient large or the marginal cost of display ads is sufficient small, then the allocation of contextual ads in a socially planned market is lower than that in a monopolized market.

Conclusion

Display advertising and contextual advertising are two important vehicles for delivering web advertisement to visitors. In this paper, we have developed an economic model to study the competence between multimedia advertising and contextual advertising in either monopolistic or duopolistic market. In a competitive market contextual advertising turns into a powerful weapon to make respectable revenue for firms concentrating on search technique, threatening the position of traditional multimedia advertising. Moreover, the equilibrium pricing decisions and resulting demand distributions are significantly associated with the

market power of the firm if these two approaches are operated by independent firms. Our analytical results show that it will be efficient to allocate users appropriately according to the relation among click thru rate, click utility and impression utility, in the absence of any pricing scheme. Socially optimal results suggest that a social planner should set catch price to motivate more clients use contextual advertising when the total market size is sufficient large.

In our model we assume that web sites allot the same advertisement space to these two ad platforms. In fact, most web sites often allocate more contextual advertising than multimedia advertising under the same space. Thus, investigating the corresponding pricing strategies under different ad space is a planned future extension. Furthermore, we also assume that the click thru rate of contextual advertising is larger than that of multimedia advertising. However, there seems to be no direct evidence to support this viewpoint. Thus, we may relax this setting to discover more interesting insights in the future study. On the other hand, if each client bids based on her budget and individual valuation, this question will be classified into Vickrey auction; thus, it is an interesting topic to study market share in the environment where the exposure rate of ads is also determined by bid value.

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