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THE HOLY GRAIL OF ADVERTISING? QUALITY SIGNALING AND REVENUE IMPLICATIONS OF “PAY-PER-PERFORMANCE” ADVERTISING

Abstract. While there is a growing stream of research examining online sponsored search advertising, an important area that has not yet received enough attention is the interplay between pay-per-performance advertising and the quality of the firms who choose to invest in it. Our objective in this work is to explore how the shift from pay-for-exposure to pay-for-performance advertising affects the ability of firms to credibly signal their quality by spending resources to acquire more prominent advertising slots. Our main result is that, in settings where a noisy signal of a firm’s true quality is available to *some* consumers before they take the action that counts as “performance” (e.g. before they click on a sponsored search link or before they make the “qualifying” phone call) if the allocation of advertising slots is made purely on the basis of firm bids, pay-per-performance advertising reduces quality signaling incentives relative to traditional pay-per-exposure. More concretely, this means that there exist settings where pay-per-exposure would induce the highest quality firms to bid more for an advertising slot, whereas pay-per-performance would induce the lowest quality firms to bid more. This is a potentially important shortcoming of pay-per-performance advertising, especially in markets with high fractions of naive consumers who are accustomed to associating higher advertising expenditures with higher quality. Empirical evidence from Google and Yahoo provides support for our theoretical predictions.

*Half the money I spend on advertising is wasted;
the trouble is, I don’t know which half.*

John Wanamaker, owner of America’s first department store

Introduction

Wanamaker’s famous quote has been the advertising industry’s favorite witticism for over a century. It now serves as the motivation behind much of the innovation taking place in Internet-based advertising. From Google and Microsoft, to Silicon Valley upstarts, some of the best and brightest technology firms are currently focusing a significant part of their energies on new tools to reduce advertising waste. These come in many forms but have one thing in common: a desire to replace the old pay-per exposure (PPE) approach, in which advertisers pay for the privilege of exposing a “theoretical” audience to their message, with one in which advertisers pay only for measurable actions by consumers. “Pay-per-click” (PPC) sponsored search is perhaps the best known and, currently, the most successful of these approaches: advertisers bid in an online auction for the right to have their link

displayed next to the results for specific search terms and then pay only when a user actually clicks on that link, indicating her likely intent to purchase. From the advertiser's perspective, this reduces some of Mr. Wanamaker's proverbial waste. "Pay-per-call" is a similar concept: the advertiser pays only when he receives a phone call from the customer, usually initiated through a web form. Pay-per-click and pay-per-call are considered by many as only an intermediate step towards the "holy grail of advertising" – the "pay-per-sale" (PPS) approach.¹

While there is a growing stream of research examining online sponsored search advertising, an important area that has not yet received enough attention is the interplay between pay-per-performance advertising and the quality of the firms who choose to invest in it. For all its bothersome traits, Wanamaker's infamous waste has one redeeming quality: in environments with quality uncertainty it can often serve as a quality signaling mechanism, differentiating high quality firms, who can afford to invest in wasteful advertising – expecting that their superior reputation and repeat business from satisfied new customers will generate positive returns on their investment – from low quality firms who cannot justify such investments (see, for example, Milgrom and Roberts 1986).

Our objective in this work is to explore how the shift from pay-for-exposure to pay-for-performance advertising affects the ability of firms to credibly signal their quality by spending resources to acquire more prominent advertising slots. Our main result is that, in settings where a noisy signal of a firm's true quality is available to *some* consumers before they take the action that counts as "performance" (e.g. before they click on a sponsored search link or before they make the "qualifying" phone call) if the allocation of advertising slots is made purely on the basis of firm bids, pay-per-performance advertising reduces quality signaling incentives relative to traditional pay-per-exposure. More concretely, this means that there exist settings where pay-per-exposure would induce the highest quality firms to bid more for an advertising slot, whereas pay-per-performance would induce the lowest quality firms to bid more. This is a potentially important shortcoming of pay-per-performance advertising, especially in markets with high fractions of naive consumers who are accustomed to associating higher advertising expenditures with

¹See, for example, "Pay per sale", The Economist, Sep. 29, 2005.

higher quality (Murthy and Zhao 2000). Fortunately, we show that PPC's ability to allow quality signaling can be restored by making the allocation of slots to firms a function of both their bids and their performance-to-exposure ratios. Empirical evidence from Google and Yahoo provides support for our theoretical predictions.

Related Work

The current surge in pay-per-performance advertising methods has generated considerable interest from both practitioners and academics. A sizable academic literature has already been forming on the topic. However, this literature has so far focused on deriving optimal bidding strategies (for example, Kitts and Leblanc 2004; Edelman et al. 2007) and deriving optimal keyword selection strategies for advertisers (for example, see references in Hosanagar and Schwarz 2007). There has however, been very little work examining the quality-signaling implications of online sponsored search advertising formats in environments with quality uncertainty. An exception is the recent empirical work by Animesh et al. (2007). Most of the work relating to advertising and quality signaling has been limited to traditional settings. Starting with the pioneering work of Nelson (1974), a substantial stream of research has examined how conspicuous advertising expenditures can enable firms to signal the quality of their offerings to imperfectly informed consumers. Kihlstrom and Riordan (1984), and Milgrom and Roberts (1986) subsequently showed that Nelson's findings of the quality-signaling role of dissipative advertising is consistent with customer rationality. In a more recent work, Linnemer (2002) extending Nelson (1974) and Milgrom-Roberts (1986) works in the contexts of non-durable goods with repeat purchases and of durable goods and finds that the presence of some informed consumers give high quality firms the same incentives to use dissipative advertising as do repeat purchases.

Main Intuitions

Consider a setting where a set of firms $i = 1, \dots, M$ compete for a limited set of advertising slots $s = 1, \dots, N$ managed by a for-profit intermediary, such as a search engine. All firms sell goods that are equally relevant to consumers; their only difference is quality. Each firm is characterized by a quality parameter q_i independently drawn from a probability distribution $f(\cdot)$. Quality determines unit cost $c(q)$ where $c'(q) \geq 0$. Each firm's own quality is private knowledge whereas the distribution of firm qualities is publicly known.

Advertising slots are ordered according to their desirability: everything else being equal, we assume that higher-numbered slots generate more revenue for all firms. This feature of the model captures the fact that some slots are more effective than others in capturing consumers' attention and are, therefore, noticed by more people and considered first. For example, sponsored search links listed at the top of a page have been determined empirically to be more likely to be noticed by consumers than search links listed further down a page. A fraction of consumers notices each slot. The fraction is exogenous and is higher for higher-numbered slots. Consumers who notice a slot form beliefs about the firm's quality. These beliefs are formed on the basis of the firm's brand name or some other external signal of quality that is visible to some consumers (the *informed* consumers) before they click a sponsored link. For example, the position of that firm's page in Google's organic search or that page's Alexa ranking can serve as such a signal. We assume that, although noisy, these signals have positive correlation with the firm's true quality. Consumers whose posterior beliefs about quality rise above a threshold click on the link and are taken to the firm's page. Let $\kappa(s_i, q_i)$ denote the corresponding *click-through rate* that is associated with a given slot s_i and a given firm quality q_i .

Once a consumer has clicked through to a firm's page she discovers product and, potentially, additional quality information provided by the firm. In this simplified setting we assume that price p is exogenously given and is, therefore, not an action variable for firms. A consumer may compare this information with that of other products before deciding which firm to purchase from. The *conversion rate* $\lambda(q_i, q_{-i})$ is thus, a function of the quality of firm i , as well as of the quality of other firms (denoted by $-i$).

We assume that the allocation of slots to firms is done through a bidding mechanism: the highest bidder is given the best slot, the second highest bidder is given the second best slot, etc. Therefore, $s_i = s(b_i, b_{-i})$. The expression of the firm's payoff function in a traditional pay-per-exposure (PPE) setting where firms pay a fixed fee to be listed, independently of the number of clicks is:²

²The following expressions imply that each firm's payment is equal to its bid. All results of this paper hold in more general settings where payments are non-decreasing functions of a firm's bid (e.g. second price auctions).

$$\Pi_{PPE}(q_i, b_i; q_{-i}, b_{-i}) = \kappa(s(b_i, b_{-i}), q_i) \lambda(q_i, q_{-i}) (p - c(q_i)) - b_i \quad (1)$$

The corresponding payoff function in a pay-per-click (PPC) setting is:

$$\Pi_{PPC}(q_i, b_i; q_{-i}, b_{-i}) = \kappa(s(b_i, b_{-i}), q_i) [\lambda(q_i, q_{-i}) (p - c(q_i)) - b_i] \quad (2)$$

In the classic quality signaling literature (Milgrom and Roberts 1986) higher quality firms signal their superior quality by spending more resources on advertising than low quality firms. In the context of our paper, our interest lies in determining the equilibrium relationship between relative firm qualities and the advertising slots they occupy and how this relationship is affected when we move from PPE to PPC advertising. Settings where higher quality firms occupy higher slots are more beneficial for consumers since they save them the costs that would otherwise be needed to search for quality.

Definition A *positive quality sorting (PQS) equilibrium* is one where the correspondence between slots and firm qualities is non-decreasing, i.e. $s_i > s_j \Rightarrow q_i \geq q_j$ for all i, j . A *negative quality sorting (NQS) equilibrium* is one where the correspondence between slots and firm qualities is non-increasing, i.e. $s_i > s_j \Rightarrow q_i \leq q_j$ for all i, j .

The concepts of PQS and NQS equilibria are very similar to the concepts of positive and negative assortative matching in assignment problems (Becker 1973). The following result is a straightforward consequence of McAdams (2003):

Theorem 1.

(a) If $\partial^2 \Pi_\gamma(q_i, b_i; q_{-i}, b_{-i}) / \partial b_i \partial q_i > 0$ for all (q_i, b_i) and all i then the corresponding game ($\gamma \in \{PPE, PPC\}$) has a PQS equilibrium.

(b) If $\partial^2 \Pi_\gamma(q_i, b_i; q_{-i}, b_{-i}) / \partial b_i \partial q_i < 0$ for all (q_i, b_i) and all i then the corresponding game ($\gamma \in \{PPE, PPC\}$) has a NQS equilibrium.

From the above theorem we can easily derive a key property that will allow us to compare the quality signaling potential of PPC relative to PPE.

Corollary 1.

- (a) If $\partial^2 [\Pi_{PPE}(q_i, b_i; q_{-i}, b_{-i}) - \Pi_{PPC}(q_i, b_i; q_{-i}, b_{-i})] / \partial b_i \partial q_i > 0$ for all (q_i, b_i) and all i then there exist settings where a PQS equilibrium exists under PPE but not under PPC.
- (b) If $\partial^2 [\Pi_{PPE}(q_i, b_i; q_{-i}, b_{-i}) - \Pi_{PPC}(q_i, b_i; q_{-i}, b_{-i})] / \partial b_i \partial q_i < 0$ for all (q_i, b_i) and all i then there exist settings where a PQS equilibrium exists under PPC but not under PPE.
- (c) If $\partial^2 [\Pi_{PPE}(q_i, b_i; q_{-i}, b_{-i}) - \Pi_{PPC}(q_i, b_i; q_{-i}, b_{-i})] / \partial b_i \partial q_i = 0$ for all (q_i, b_i) and all i then if a PQS equilibrium exists under PPC, it also exists under PPE and vice-versa.

Applying Corollary 1 to (1) and (2) we obtain:

$$\frac{\partial^2 [\Pi_{PPE}(q_i, b_i; q_{-i}, b_{-i}) - \Pi_{PPC}(q_i, b_i; q_{-i}, b_{-i})]}{\partial b_i \partial q_i} = \kappa_2(s(b_i, b_{-i}), q_i) + b_i \kappa_{12}(s(b_i, b_{-i}), q_i) s_1(b_i, b_{-i})$$

where subscripts indicate partial derivatives.

By definition it is $s_1(b_i, b_{-i}) \geq 0$. The preceding discussion also implies that $\kappa_2(\cdot, q_i) \geq 0$. Finally, in most practical cases it will be $\kappa_{12}(s, q) \geq 0$. For example, if the click-through rate is the product of a term that depends only on the slot s (i.e., probability of noticing) and a term that depends only on quality q , this holds. The derivatives of $\kappa(\cdot, \cdot)$ are strictly positive if click-through rates have a positive correlation with a firm's true quality, above and beyond what can be implied by consumers by the advertising slot it occupies. This may happen, for example, if good firms have a brand that is recognized by a subset of consumers, if good firms appear more often near the top in organic search (and, at least *some*, consumers perceive this as a signal of quality), if the search engine publishes summaries of consumer reports next to the sponsored links (see, for example, www.froogle.com), etc. In all these cases, some consumers have access to a signal of a firm's true quality that makes them more likely to click sponsored links of better quality firms, conditional, of course, on having noticed the presence of the link. The resulting complementarity between slot position and quality means that better firms have a higher marginal benefit from occupying a higher slot.

In PPE advertising this complementarity contributes to the existence of a PQS equilibrium since it increases the ability of higher quality firms to bid higher amounts for a given slot. In contrast, in PPC advertising firms only pay for clicks and, therefore, any complementarities between slot position and quality that might exist in click-through rates, become irrelevant. In PPC, advertising firms' relative willingness to pay for a slot is primarily determined by the product of the conversion rate times unit profit. If the dependence of conversion rates on quality is weak (for example because there is little *additional* credible quality information that can be communicated to consumers *after* they visit a firm's page) and if unit profits do not increase with higher quality (for example, because prices are fixed and unit costs increase with higher quality) then it is possible to have outcomes where PPE advertising induces PQS equilibria, whereas PPC advertising induces non-monotone or even NQS equilibria. In such settings PPC advertising deprives good quality firms of the ability to signal their quality by occupying a higher slot. In fact, higher slots will then be occupied by low quality firms. This increases the likelihood that consumers that are accustomed to associate advertising with quality will make suboptimal choices. This discussion leads to the following important result:

Theorem 2. *If some consumers have access to a noisy signal of a firm's true quality before deciding whether to click on a sponsored link and if the allocation of advertising slots to firms is made exclusively on the basis of their bid amounts then there exist settings where PPE advertising admits a PQS equilibrium but PPC advertising does not.*

One way to restore quality signaling under PPC advertising is to reintroduce the quality signal that is "lost" through PPC into the payment that a firm needs to make in order to secure a particular advertising slot. As before, we assume that advertising slots are allocated to firms according to their bid amounts. However, the payment that a firm of quality q_i needs to make to secure slot s is now equal to $x_i = b_i/h(s, q_i)$, where $h(s, q_i)$ is a function determined by the intermediary, based on the intermediary's partial knowledge of a firm's true quality. The modified payoff function in a pay-per-click (PPC) setting is:

$$\Pi'_{PPC}(q_i, b_i; q_{-i}, b_{-i}) = \kappa(s(b_i, b_{-i}), q_i) \left[\lambda(q_i, q_{-i})(p - c(q_i)) - \frac{b_i}{h(s(b_i, b_{-i}), q_i)} \right] \quad (3)$$

Comparing the PPE and modified PPC payoff functions we obtain:

$$\Delta = \Pi_{PPE}(q_i, b_i; q_{-i}, b_{-i}) - \Pi'_{PPC}(q_i, b_i; q_{-i}, b_{-i}) = b_i \left[\frac{\kappa(s(b_i, b_{-i}), q_i)}{h(s(b_i, b_{-i}), q_i)} - 1 \right]$$

If we set $h(s(b_i, b_{-i}), q_i) = \kappa(s(b_i, b_{-i}), q_i)$, that is, set each firm's payment to be equal to its bid divided by its expected click-through rate, the above difference Δ , and thus, its cross-partial derivative with respect to (q_i, b_i) become zero. The following important result then follows from Corollary 1(c):

Theorem 3. *A PPC advertising scheme where higher slots are allocated to higher bidders but where each firm's payment is equal to its bid divided by its expected click-through rate when occupying its assigned slot, has the same ability to signal quality than a PPE scheme where higher slots are allocated to higher bidders and payments are equal to bids.*

Theorem 3 assumes that firms and the intermediary are able to correctly predict the click-through rates that are associated with any given firm and any given advertising slot. In the context of sponsored search this is a realistic assumption. Recall that firms bid for slots on individual user searches. The huge number of searches conducted daily allows both the firms and the search engines to compile extensive empirical click-through rate data after a few days of experimentation. Google and, more recently, Yahoo have been applying such a modified allocation rule to their sponsored search links. Specifically, these search engines allocate slots to firms according to the product of each firm's bid and a "quality factor", whose exact definition remains a trade secret, but which appears to correlate highly with empirically observed click-through rates. The initial motivation for this modified scheme was to increase the percentage of sponsored links that were "relevant" to the user's keywords. We are the first ones to show that this scheme also has beneficial consequences for the ability of PPC advertising to signal quality.

Empirical Evidence

Empirical results from Yahoo and Google provide evidence that supports our theory. Yahoo! and Google use different methods for allocating sponsored link slots to firms. Yahoo! allocates slots according to bids, whereas Google allocates slots according to the product of each firm's bid and a "quality factor" that correlates with that firm's historical click-through rates.³ Using different measures of advertiser quality we examine the relationship between an advertiser's ranking within the sponsored search listings for a set of relevant keywords, and his quality. Following Nelson (1970) we distinguish between three categories of advertisers:

- search goods (e.g., cameras, laptops, books)
- experience goods (e.g., auto insurance, real estate brokers, carpet cleaners)
- credence goods (e.g., psychics, attorneys, therapists)

The three categories are characterized by increasing difficulty of credibly communicating quality to consumers through information offered by the advertiser on their pages (and, therefore, viewed *after* users click on the advertiser's link). Under the assumption that there exist at least *some* informed consumers, so that click-through rates are a positive function of both a firm's position and true quality, our theory predicts the following:

- H1. As we move from search goods to credence goods, PPC advertising will be increasingly unable to sustain PQS equilibria on Yahoo!
- H2. Google's "quality factor" adjustment will be able to sustain PQS equilibria for all three advertiser categories

Figure 1 summarizes our empirical results. Figure 1(a) shows that, on Yahoo!, there exists a positive relationship between an advertiser's quality and position for search goods. However, this relationship becomes more ambiguous for experience goods and finally becomes negative for credence goods. This is consistent with H1. In contrast, on Google, the relationship between quality and position remains positive for all three categories of goods. This is consistent with H2. Our empirical results, thus, provide striking evidence for the

³Yahoo! changed its ranking mechanism to a mechanism similar to Google's sometime in Feb. 2007. However, the data for our study was collected in late 2006, when Yahoo! still used a pure market mechanism to rank the advertisers in its sponsored search listings.

validity of our theory.

Conclusions and Research Plan

The rising popularity of pay-per-performance (PPP) advertising methods requires a careful evaluation of their advantages and disadvantages relative to more traditional, pay-per-exposure (PPE) methods. Our study is the first one to look at the relative abilities of the two methods to act as quality signaling mechanisms. Our initial results suggest that PPP reduces the relative ability of firms to signal quality to consumers through higher advertising spending. This is especially true in settings where the signaling qualities of PPE are due to the presence of some informed customers that know something about a firm's true quality before clicking on its link and where a firm's ability to credibly signal its quality through direct information provided to consumers (after they click its link) is limited. PPP's quality signaling ability can be restored by the intermediary by making the allocation of slots to firms a function of both their bids as well as their historical performance-to-exposure ratios.

The full paper will expand on the ideas presented in this report and will explore additional research questions. Specifically, the full paper will contain a detailed model that will serve as an example of our general ideas and results. The detailed model will describe a concrete setting where PPE advertising admits a PQS equilibrium, whereas PPC advertising admits a NQS equilibrium. The implications for the intermediary, firm profits and consumer welfare will be derived and discussed. We will then show how modified slot allocation rules that take into account both a firm's bid and quality can restore the existence of a PQS equilibrium under PPC advertising. We will explore the general problem of pricing pay-for-performance advertising so as to maximize the intermediary's advertising revenues subject to maintaining the existence of a PQS equilibrium. Finally, we will explore the revenue and quality signaling implications of competition between PPE and PPC advertising products offered by the same or by competing intermediaries.

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FIGURE 1
Relationship Between Quality and Position Across SEC Goods
Figure 1a: Yahoo

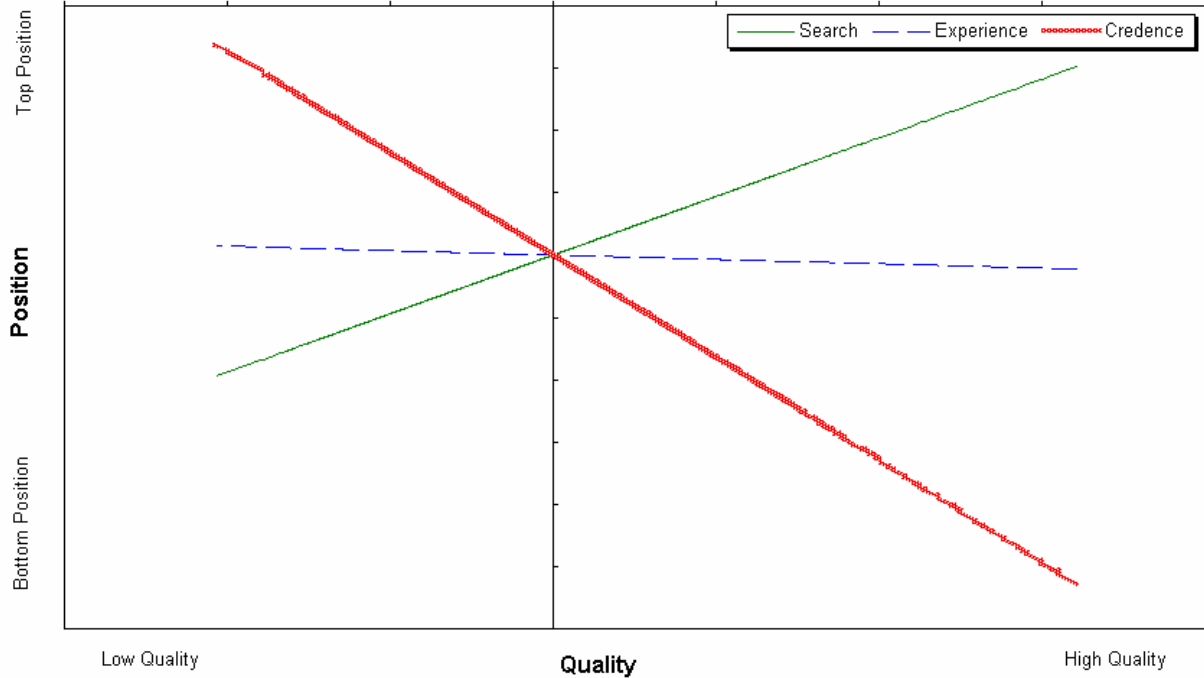


Figure 1b: Google

