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Quality Uncertainty And Adverse Selection In Sponsored Search Markets

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QUALITY UNCERTAINTY AND ADVERSE SELECTION IN SPONSORED SEARCH MARKETS*

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ABSTRACT

Sponsored search mechanisms, where advertisers bid for placement to be as close to the top in the listing of search results, are the fastest growing among online search models. Sponsored search in popular search services such as Google and Yahoo! employ an auction mechanism wherein firms can bid, for a better placement in the (sponsored) search results, on relevant keywords used by consumers in their search process. This provides an unprecedented opportunity to test some of the predictions of earlier research relating quality and advertising, in the online setting. While sponsored search mechanisms have been gaining popularity, they can potentially introduce a bias in the listing of search results. In particular, sponsored search mechanisms that enable low quality bidders to be placed at the top of the search listings can adversely affect consumer welfare. Our study uses data from online sponsored search auctions to examine the relationship between advertisers' quality and their bidding strategies. Specifically we seek to understand if advertisers' bidding strategies differ across products characterized by different degrees of quality-uncertainty. Our results indicate that there are significant differences in the bidding strategies of sellers of *search* goods as compared to sellers of *experience* and *credence* goods, and that there is significant adverse selection in product categories characterized by greater uncertainty. We discuss the implications of our findings for consumers, advertisers, and intermediaries and provide directions for future research in this emerging context.

Keywords: sponsored search, keyword advertising, pay-for-performance, search, credence, experience

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1. INTRODUCTION AND MOTIVATION

It is well known that the Internet and electronic marketplaces have dramatically lowered the cost of consumers obtaining information about product offerings and prices as well as the cost of sellers communicating such information. Of the various Internet-related technologies, search engines such as Google and Yahoo! have occupied a central role in the consumer search process. According to a recent study by comScore Networks¹, nearly 4 billion online searches are conducted each month using search engines. The power of search engines such as Google is best illustrated by the following quote.

*“Patrick Ahern has witnessed the power of Google -- and the difficulties of trying to do business without it. Data Recovery Group, where he is president, would typically come up around the fourth listing on Google's popular search engine last year. Then in January, when Google removed the company from its listings without explanation, Data Recovery saw a 30 percent drop in business. So powerful has Google become that many companies view it as the Web itself: If you're not listed on its indexes, they say, you might as well not exist.”*²

Popular search engines like Yahoo!, Altavista, AskJeeves, and Google have largely been an outgrowth of academic research and development projects in information retrieval. Traditionally these search services have used “crawler-based” search mechanisms that create their lists based in a complex set of algorithms that attempt to maximize the relevance of their search results to a user. These *organic* search mechanisms typically consist of (i) *a crawler* or spider that visits web pages, (ii) *an index* containing a copy of every Web page that the crawler finds and (iii) *the search engine software* program that sifts through the millions of indexed pages to find the relevant matches to a

¹ Source: <http://www.enquiro.com/net-profit/Defending-Organic-Search.asp>

² Source: “Does Google’s Power Threaten the Web?”, CNET News.com

query. However they differ in the number of Web pages indexed as well as in the algorithm they use to rank their search results. *Organic* search engines such as Google have grown to become one of the largest and most widely used search engines owing primarily to the superiority of their search algorithms that provide highly relevant search results to consumers. These search engines have historically provided their services for free, while being supported by revenues from advertisers and from selling consumer search-related information. Competition among these different search mechanisms has consequently focused on the superiority of their search algorithms and their ability to provide relevant search results to users. In keeping with this, most of the existing literature has focused on the technological aspects of these search mechanisms.

More recently, with the slump in online advertising and alternate revenue streams, a new business model for search has been rapidly gaining popularity. One of the fastest growing search mechanisms has been the “sponsored search” (also known as “pay-for-placement” or “keyword advertising”) model where advertisers bid for placement (to be as close to the top) in the listing of the search results³. The paid-search market is projected to more than double over the next three years, to \$5.4 billion, making up 60% of the U.S. online advertising market⁴. The recent acquisition of Overture by Yahoo! for \$1.6 billion further highlights the industry’s belief in the potential of the sponsored search model.

One of the interesting aspects of sponsored search (keyword advertising) mechanisms is the integration and co-evolution of online *search* and *advertising* business models. Given that search engines have become the starting point for Internet navigation, it is not surprising that advertisers have been trying to garner the attention of online consumers through advertisements on the search

³ While organic search engines like Google too carry advertisements, the ads are unobtrusive and are confined to a small box on the side of the screen.

⁴ Source: “The Search War is About to Get Bloody”, Business Week, July 28, 2003

engine result pages. In addition to being able to reach a vast audience, advertising on a search engine enables firms/advertisers to target potential customers who are *actively* searching for a particular product/service. The sponsored search model, generally, employs an auction mechanism wherein firms/advertisers can bid, for enhanced placement in (sponsored) search results, on relevant keywords used by consumers in their search process. Each advertiser pays the bid amount for each click-through but is not charged for the exposures. The higher the bid, the higher the advertiser's message (usually a link to the advertiser's URL) appears in the results, which should typically lead to more sales leads (click-throughs) and consequently greater sales.

Analysts believe that sponsored search overcomes several of the deficiencies in organic search including lack of context related information, and lack of adequate information about quality. A recent study⁵ showed that click-through rates of sponsored search are 4 times that of organic search, and conversion rates are twice that of organic search. While the sponsored search mechanism has been growing rapidly, it differs from traditional (media) advertising in a number of significant ways. For instance, the payment structure (pay-for-performance), the sequential ordering of ads based on advertiser's willingness to pay, constraints on the amount and type of information that can be displayed, and most importantly the active search by consumers make online "pay-for-performance" or sponsored search/advertising models different from advertisements in traditional broadcast and print media. Proponents of pure organic search believe that sponsored listing and pay-for-placement search models have a questionable future as they flout time-tested business practices that require an absolutely clear separation between editorial content and advertising⁶. According to them, "users get less of what they're looking for and more of what someone else wants them to see". In a response to

⁵ Source: <http://www.enquiro.com/net-profit/Defending-Organic-Search.asp>

⁶ Source: "Search Me: Doom Ahead for Search Engines that Charge Listing Fees", San Francisco Chronicle, January 2002.

growing concerns and the importance of search services online, the FTC recently recommended that search engines improve disclosure of paid content within search results.

Despite the rapid growth of sponsored search and the importance of online search mechanisms for the emerging economic and competitive landscape online there has been surprisingly little research on the implications of these sponsored search mechanism for consumers and firms. Given the controversies surrounding sponsored search mechanisms, and in light of emerging issues relating to organic and sponsored search, it is important to gain a better understanding of the implications of sponsored search mechanisms for its participants as well as for policy makers.

1.2. Research Issues

The presence of paid results in online search engines presents a new kind of informational problem in the digital realm. It is not surprising that a large number of consumers are unaware that in every search, paid listings are proffered along with algorithmic or organic listings. While search engines vary in their policy regarding the ordering and quantity of search listings, all of them are now required to highlight the sponsored results that they display.

The emergence of sponsored search (keyword advertising) as a viable alternative not only to organic search but also to traditional advertising raises several issues of interest to academicians as well as practitioners. Sponsored search mechanisms provide significant revenues to search engines, but can potentially introduce a bias in the listing of search results, in the process, reducing the potential value of search to consumers. Gaudeul (2004) discusses the inherent conflict of interest in this advertising model, where the information intermediaries deliver information about a seller's product, but are paid by those same sellers they "certify".

Sponsored search auctions that enable low quality bidders to be placed at the top of the search listings can adversely affect consumer welfare and reduce the utility of such mechanisms for consumers. When consumers turn to search engines as their starting point for information search on products and services that they are interested in purchasing at some later point, how trusting are they of the search results displayed to them? This would depend on how credible the signals displayed by online merchants and retailers that advertise on search engines are. The success of the sponsored search mechanisms and the optimality of their design critically depend on understanding the nuances of firms' bidding behavior, and the drivers of firms' bidding strategies in the online keyword auctions.

Traditional theories of advertising suggest that in addition to providing information to consumers, advertisements can also serve as an effective signaling mechanism. While there exists a large body of literature in economics and marketing that studies the relationship between advertising and quality in markets characterized by imperfect information, the results are inconclusive. The bids by advertisers (for placement in search engines listings) serve as an excellent proxy for online advertising spending of firms. Thus, data on bids by advertisers collected from sponsored search auctions in different product categories provide an unprecedented opportunity to test some of the predictions of earlier research relating quality and advertising levels, in the online setting.

Our research seeks to understand the bidding strategies of firms in online sponsored search auctions. One of the primary objectives of this research is to understand how *firm* as well as *product* characteristics influence advertisers' bidding strategies in sponsored search auctions. Specifically, we examine the relationship between advertisers' quality and their bidding strategies and more importantly, if advertisers' bidding strategies differ across products characterized by different degrees of quality-uncertainty. Building upon existing theories of advertising in traditional media,

our findings also provide insights into the effectiveness of “performance-based” advertising across different regimes of quality uncertainty.

The rest of the paper is organized as follows. §2 provides a brief review of prior research on advertising and quality uncertainty. §3 describes the characteristics of our data and our methodology for examining seller bidding strategies. §4 describes the results of our empirical analyses. §5 summarizes the key insights from our study and discusses the implications of our findings. §6 provides directions for future research and concludes.

2. A BRIEF REVIEW OF RELATED RESEARCH

One of the primary roles of advertising is to provide information about products and services to consumers. In addition, advertising is also known to serve as a signal for quality, enabling consumers to differentiate between high-quality and low-quality sellers. This role of advertising as a signaling mechanism takes on greater significance in purchase situations characterized by greater uncertainty. Thus the dynamics of competition among advertisers is likely to differ across purchase situations or product categories characterized by different degrees of uncertainty. Most of the existing work in advertising has focused on traditional media. However, given the differences between conventional and online channels, consumers may or may not perceive advertising signals in the same manner. The lack of sensory cues in the online channel is also likely to exacerbate the uncertainties involved in shopping for various product categories.

2.1. A framework for product categories

The search-experience-credence goods (SEC) framework has been widely used in the economics and marketing literature to examine consumer search behavior as well as firms advertising strategies. According to the SEC framework, attributes of goods can be analyzed in terms of three properties – *search*, *experience*, and *credence* (Darby and Karny 1973; Nelson

1970). “These properties are used to categorize the point in the purchase process when, if ever, consumers can accurately assess whether a good possesses the level of an attribute claimed in advertising” (Ford et al. 1990). Search goods have characteristics that are identifiable through inspection and prior to purchase. Experience goods, on the other hand, have features that are revealed only through consumption. The fact that consumers can never be certain of the quality and value of credence goods purchased even from ex post observations, differentiate credence goods from experience and search goods.

The SEC classification is particularly useful in examining the role of information provision and market performance, as well as in examining the influence of media on consumer search process (Klein 1998). It is pertinent to note that the boundaries between these categories are fuzzy, and the categories represent regions in a continuum. The three product categories primarily represent the uncertainty characterizing the purchase of these products -- where the uncertainty increases as we move from search to experience and experience to credence goods -- and the consequent implications for information provision and advertising.

Insofar as consumer behaviors drive firm’s advertising and marketing strategies, it is essential to understand how consumers search across product categories. Prior research suggests that consumer search behavior is likely to be different across search, experience, and credence goods. In particular, there is a systematic difference in the marginal benefits to a consumer from the search for experience goods and from search for search goods (Nelson 1974). To the extent that advertisements are informative, a consumer will look at an advertisement if the marginal benefit is greater than the cost (time and effort) involved in examining and processing the advertisement (Nelson 1974). Since consumer search strategies drive advertisers’ strategies (Ford et al. 1990), any systematic differences

in consumer search (information seeking) strategies are likely to be reflected in advertisers' strategies as well.

2.2. Advertising and Search

Studies on firm advertising strategies in traditional channels posit the use of different mechanisms by sellers across search, experience and credence product categories (Ford et al. 1988, 1990). Search goods, as defined within the SEC framework, have low pre-purchase uncertainty. Therefore, the advertisers for search goods primarily resort to informative advertising to promote differentiation amongst products. At equilibrium, a low quality firm will not be able to sustain high levels of advertising as consumers can easily ascertain the quality of goods before purchase. Consequently, we would expect a positive relationship between firms' quality and advertising expenditure for search goods.

On the other hand, experience and credence goods are characterized by higher uncertainty requiring sellers of these goods to signal their quality to help reduce the uncertainty. Sellers of experience and credence goods typically resort to dissipative advertising, or mechanisms that provide indirect information about quality, by means of signaling. Firms may use various signaling mechanisms such as pricing (Woolinsky 1983), warranty (Grossman 1981), advertising (Nelson 1974), selling through reputable retailers (Chu and Chu 1994) or any combination of the above.

Both analytical modeling and empirical studies are mostly inconclusive regarding the relationship between firm quality and their advertising levels. Pioneering work by Nelson (1974) showed that in the presence of high levels of uncertainty associated with the good, high-quality brands will spend more on advertising in equilibrium than low-quality brands. Since the benefits from advertising are higher for goods with greater uncertainty, high quality firms will find it

beneficial to signal their quality. Thus advertising expenditures were thought to be positively related to quality. This positive relationship between quality and advertising levels typically hold when there are *repeat purchases* (Johnsen 1976; Nelson 74), *a large proportion of informed consumers in the market* (Johnsen 1976; Linnemer 2002), and *differences in cost structures of high quality and low quality firms* (Kihlstrom and Riordan 1984; Linnemer 2002).

The failure to meet one or more of the abovementioned conditions, along with the presence of high uncertainty, renders the signaling mechanism ineffective, causing high quality sellers to drop out of the market. Thus in markets with adverse selection, low quality sellers drive out higher quality sellers leading to a market breakdown (Akerlof 1970). When there is a high proportion of naïve consumers, and one-shot purchases, lower quality firms will typically find it optimal to advertise more, due to their lower cost structures, as compared to high quality sellers. Researchers have suggested that in these cases there exist equilibria in which the lower quality brands advertise the most (Schmalensee 1978; Comanor and Wilson 1979).

In summary, advertising strategies for sellers of search goods are likely to be very different from those for sellers of experience and credence goods. The SEC framework is therefore, very useful in understanding the relationship between quality and advertising levels.

3. DATA

3.1. Data collection

Overture (currently owned by Yahoo!) is the oldest and one of the largest sponsored-search mechanisms raking in an estimated \$1 billion by auctioning placement in search results to a network of over 88,000 advertisers. It also distributes its listings to a wide-range of major search engines, including AltaVista, AOL Search, Lycos, and Netscape Search. Overture uses a continuous open-bid auction where advertisers can bid for placement in Overture's search listings for a particular

search term(s). The higher the bid, the higher the placement on the listing of search results.

Overture displays the maximum bid of each advertiser on its search results pages. As described earlier, advertisers bid for specific keywords related to their product/service to get better placements in the search results. In addition, higher ranked search results (higher bidders) also get displayed at affiliated websites with higher traffic ranks.

Following the search, experience and credence framework, we selected a total of 36 products, and classified each good in one of the three categories as commonly used in marketing literature. The products used in this research are borrowed from Ekelund, Mixon and Ressler (1995) and are listed in Table 1. However, a few modifications to the product types were required in order to ensure that the products considered here received sufficient bids from keyword advertisers. We then collected daily data on advertisers' bidding strategies for each of these products/keywords from the sponsored search results for a period of 60 days. We collected data relating to the bidder (the advertiser), the search terms, the bid amount, the time of the bid, and the ranking within the search results. We restricted our focus to products that have a sufficient number of advertisers bidding for keywords representing the specific products, and also discard any firms that bid less than 20 days for each of the keywords.

The data on firm quality was gathered from Alexa.com and consists of traffic ranks, consumer website ratings, the number of incoming links to a website, along with detailed measures for page reach and range and the change statistics for all of the above measures over different time periods (3 months, 1 month, 1 week and 1 day). Alexa collects this data from the users that participate and contribute this information by using the Alexa toolbar. Prior research in IS has employed Alexa data as a proxy of website quality (Palmer 2002) as well as proxy for firm's brand equity or social capital (Palmer et al 2000).

3.2. Measures

The description of the measures collected and created is found in Table 2. The firms are ordered by their average rank in the sponsored search listings over the period of our data collection (not including the days that they did not bid) and the top twenty ranked firms (positions described by variable POSITION⁷) are then selected to form a smaller subset. In this study we focus on the top 20 ranked firms in each product category (SEARCH, EXPERI, and CREDEN).

We capture the advertisers' bidding strategies using a set of variables that represent the dynamics of the bids placed and the ranks obtained by the sellers in the search listings. The three specific variables that characterize firms' bidding behaviors are LNAVGBID, LNBIDDEV, and LNRNKDEV. LNAVGBID is the average bid placed by the firm over the period that bid data was collected for, excluding the days that it did not participate in bidding during the data collection period. To calculate LNBIDDEV, we first calculate percentage bid differences between two consecutive days for each of the days that the firm placed bids (BIDDIFF), and then use the standard deviations of these relative bid changes. We perform similar calculations to determine the rank deviations for a firm, LNRNKDEV. These three variables are log-transformed. The deviation measures thus calculated provide a measure of the volatility associated with the bids placed and the ranks obtained. While these two maybe correlated in some instances, they need not always be so. For example, while placed bids are solely determined by the firm itself, its rank in the search listings is a function of not only its own bid but also that of all other firms participating in the sponsored search auction for a given keyword.

⁷Note that the naming of this variable may be a source of confusion in that this is reverse coded, as in a lower value of POSITION represents a better ranking, or higher position in the listings

Merchant website quality is captured through measures like the number of incoming links to a firm, or INLINKS, average user or customer ratings received by a firm on a scale from 0 to 5, or USERRATI, and its traffic rank, TRAFFICR⁸. These three measures are collected from Alexa, an Amazon.com company that provide web information services by analyzing the Web usage of millions of their toolbar users. The first of these quality measures, number of in-links has been popularized by search intermediaries like Google and others that use the number and quality of the links pointing in towards a firm as a measure of the website quality. We use these measures as a proxy for seller quality. Customers visiting seller websites also rate their purchase and shopping experiences, which Alexa averages over all ratings to produce a user-rating score for the seller's website. Overall traffic rank is a combination of historical page view rank (fraction of all the page views by toolbar users go to a particular site, per million) and page reach, which measures the number of users (percentage of all Internet users who visit a given website) of the website. These three quality measures are found to be highly correlated, and for the purposes of our analysis, we only use traffic rank, as it is the most reliable and complete among the three. Table 3, provides summary and description of these measures.

3.3. Methods and analysis

We use regression analysis to examine whether the firms' bidding strategies and their outcomes differ across product types, website quality, and the position in the listings. The firms' bidding strategies, specifically, average bids, bid volatility, and rank volatility are used as dependent variables in the following models, described in Table 4. The first two models, 1a and 1 b, define average bid as a function of product type, website quality, and position of the firm (normalized by number of competitors in a particular keyword market), and the interactions

⁸ This number is reverse coded, such that higher values indicate lower quality

among product type and the quality measure, traffic rank. Since average bid, is by definition, correlated with POSITION, we do not include interactions with the POSITION variable, although we include the main effect as a control. Since we are also interested in determining the bidding dynamics at different positions, we treat this variable as exogenously given.

$$\begin{aligned} \mathbf{LNAVGBID} = & \alpha + \beta_{11}\mathbf{NPOSITION} + \beta_{12}\mathbf{EXPERI} + \beta_{13}\mathbf{CREDEN} + \beta_{14}\mathbf{LNTRFFIC} + \\ & \beta_{15}\mathbf{EXPERI*LNTRRFIC} + \beta_{16}\mathbf{CREDEN*LNTRRFIC} + \varepsilon_1 \end{aligned} \quad (1)$$

Models 2a and 2b define bid volatility (as measured by bid deviation) as a function of all previous independent variables as well as average bid. In addition, we also include interactions among product types and the position of firms in the listings of the search results.

$$\begin{aligned} \mathbf{LNBIDDEV} = & \alpha + \beta_{11}\mathbf{NPOSITION} + \beta_{12}\mathbf{EXPERI} + \beta_{13}\mathbf{CREDEN} + \beta_{14}\mathbf{LNTRFFIC} + \\ & \beta_{15}\mathbf{EXPERI*LNTRRFIC} + \beta_{16}\mathbf{CREDEN*LNTRRFIC} + \beta_{17}\mathbf{EXPERI* POSITION} + \\ & \beta_{18}\mathbf{CREDEN* POSITION} + \beta_{19}\mathbf{LNAVGBID} + \varepsilon_1 \end{aligned} \quad (2)$$

Models 3a and 3b define rank volatility as a function of all the previous variables as well as bid deviation.

$$\begin{aligned} \mathbf{LNRNKDEV} = & \alpha + \beta_{11}\mathbf{NPOSITION} + \beta_{12}\mathbf{EXPERI} + \beta_{13}\mathbf{CREDEN} + \beta_{14}\mathbf{LNTRFFIC} + \\ & \beta_{15}\mathbf{EXPERI*LNTRRFIC} + \beta_{16}\mathbf{CREDEN*LNTRRFIC} + \beta_{17}\mathbf{EXPERI* POSITION} + \\ & \beta_{18}\mathbf{CREDEN* POSITION} + \beta_{19}\mathbf{LNAVGBID} + \beta_{20}\mathbf{LNBIDEV} + \varepsilon_1 \end{aligned} \quad (3)$$

Although there may well be reason to suspect non-orthogonality between regressors and the error terms, the use of IV estimation to address this problem must be balanced against the inevitable loss of efficiency vis-a-vis OLS. If there exist correlations between the right hand side variables and the error terms, these violate the OLS assumption that the predictors be uncorrelated with the error term. In this case, the OLS estimates will be inconsistent and thus

OLS is not desirable. It is therefore very useful to test whether or not OLS is inconsistent and another estimation technique such as Instrumental variables or IV is required.

To test for the presence of endogeneity, we conduct Durbin-Wu-Hausman test (Davidson and MacKinnon (1993)). Under the DWH test, we first determine the potential endogenous variables in the model and control for such endogeneity using a procedure such as instrumental variables estimation. The total number of unique firms is introduced as an instrument that is correlated with the endogenous variables, average bid and bid volatility. The test is based on the difference between parameter estimates with and without controlling for potential endogeneity. The null hypothesis is that parameters estimated without controlling for endogeneity are consistent. Rejecting the null hypothesis implies endogeneity of the explanatory variables. The DWH test statistic can be specified as: $H = (\Phi_{OLS} - \Phi_{IV}) [var(\Phi_{OLS}) - var(\Phi_{IV})]^{-1} (\Phi_{OLS} - \Phi_{IV})$, where, Φ_{OLS} is the vector of estimated parameters without controlling for endogeneity and Φ_{IV} is the vector of consistent parameter estimates using IV (treating average bids and bid volatility as endogenous). Under the null hypothesis, H is asymptotically distributed as $\chi^2(g)$, where g is the number of potentially endogenous variables. In this paper, we use the DWH test procedure, and reject the presence of endogeneity for all equations.

Based on these results we conclude that regression tests are appropriate to estimate the proposed models. Further, since the Breusch-Pagan (a.k.a. Cook's Weisberg's) test indicate the presence of heteroskedasticity in all the models, we run regressions using robust standard errors (using the Huber-White sandwich estimator), which ensures that the estimates of the standard errors are more robust to the failure to meet assumptions concerning normality and homogeneity of variance of the residuals.

We describe these analyses next. Our total sample for the analysis is 720 observations, from the top twenty ranked firms for 36 product keywords. After accounting for missing values, the regression models were estimated using 662 observations.

4. RESULTS

We find that firms' average bid differs across products types and there seems to be an "inverted-U" relationship between increasing uncertainty and average bids. More specifically, we find that experience goods have highest average bid, followed by credence and search goods. Typically, a firms' willingness to bid higher is a function of profit margin and/or higher sales at the higher positions. Given that firms incur costs-per-click, irrespective of the outcome, being listed in higher ranks or top slots for informational purposes may not be an optimal strategy, as observed by the average bids of credence good bidders. Our results thus imply that experience goods sellers enjoy higher conversion rates and/or higher profit margins.

Advertisers' qualities are found to be unrelated to the average bids placed by them. Interestingly, this result contradicts the conventional wisdom that higher quality firms tend to advertise more. A closer investigation reveals that the relationship between an advertiser's quality and its average bid is moderated by the product type. We find that lower quality firms bid higher than high quality firms in the case of *experience* and *credence* goods. However, high quality sellers of search goods are found to bid higher than low quality sellers of *search* goods. This is an interesting finding given that results of prior research have been inconclusive.

We then examine whether firms deviate in the bids they place across the days in the observation period. We find that firms with high average bids (i.e. firms that are ranked higher in the search listings) have higher bid volatility. Further, we find that bid deviation differs across product types, with highest variations for search goods, followed by credence and experience goods. Firm's quality

was found to be a significant predictor of bid volatility. We find that high quality firms have higher bid volatility as compared to low quality firms. The differences in bid deviations across sellers of different product categories and different qualities indicate that search good sellers (and high-quality sellers) actively manage their bids as compared to credence and experience goods sellers.

The result that search goods have higher bid volatility is driven by the effect of higher quality firms having higher bid deviations. The search goods have, on an average, higher quality firms (as seen from the results of the regressions on LNTRFFIC in models 4a and 4b), which have higher bid deviations. This makes the average bid volatility for search goods larger than the experience and credence goods.

Finally, we analyze how sellers appear to move across the sponsored search listings in terms of their rank volatility. We find that firms with high average bids have higher rank deviations. This is consistent with the bid volatility results above. We also find that firms ranked higher exhibit higher rank deviations. Further, though not statistically significant, experience and credence goods exhibit higher rank deviations at the top ranks/positions as compared to search goods. This implies that there is higher competition, in general, in the top ranked positions of sponsored search listings.

Rank volatility (similar to bid volatility) differs across product types. We find that credence goods have higher rank volatility than search or experience goods. In other words, both search and experience goods have consistent/stable rankings compared to credence good sellers. Previous result shows that search goods have higher bid volatility as compared to credence and experience goods. The two findings indicate higher competition among search good firms, and that they monitor and change their bids to maintain their position. Hence we see higher bid deviation and lower rank deviation for search goods as compared to experience and credence goods.

It is important to note that though the total number of unique firms is highest in the case of experience goods, they still have the lowest bid volatility and comparatively low rank volatility. This implies that they do not need to actively monitor and change their bids in order to maintain consistent or stable rankings. Lastly, we also find that there is significantly larger number of new entrants as well as larger number of firms exiting the auction for credence goods. This could lead to higher rank volatility for credence goods, despite lower bid volatility.

Consistent with the finding regarding the dynamics of bid volatility, we observe that high quality firms have higher rank volatility compared to low quality firms.

5. DISCUSSION AND IMPLICATIONS

This paper contributes to the existing literature on e-commerce as well as advertising in a number of ways. We study an exciting and new phenomenon that is rapidly becoming a dominant business model on the Internet. This study examines the relationship between a firm's level of bidding (i.e. advertising intensity/expenditure) and its quality, in the context of sponsored search/advertising. In doing so, it contributes to the literature on advertising by testing traditional theories in emerging channels. We find significant and interesting results that show how quality-uncertainty plays an important role in determining firms' bidding strategies.

An interesting finding is that firms' average bid differs across products types and there appears to be an "inverted-U" relationship between increasing uncertainty and average bids. This is likely a result of differences in product categories in terms of their profit margins and click-through and conversion rates. Our results indicate that experience goods have the highest value/benefit from appearing in the sponsored search results. Future research should systematically analyze consumer search behavior across these product categories to validate

these findings and also to identify reasons for differences in profit margins, click-throughs, and conversion rates across product types.

Our finding that high average bids (i.e. at the top ranks) have higher bid volatility and higher rank volatility suggests that competition is more intense for the top positions, across all product categories. Firms that bid high appear to be actively managing their bids in an effort to maintain or move up in the ranking of search results. Heightened competition is likely to cause a firm to bid more than is optimal for the firm at that position, benefiting the search service provider.

Further, high-quality firms manage their bids more actively than low quality firms. This suggests that sponsored search rankings might be more significant for high-quality firms. Given, the dynamic nature of online markets, it is also possible that only high-quality firms have the ability to undertake sophisticated data analysis and forecasting to maximize their returns from their online investments.

One of the most interesting findings is that lower quality firms bid higher in the case of experience and search goods suggesting that some of the concerns regarding sponsored search mechanisms are valid. Allowing firms to bid for placements in search results introduces a bias in the listing of search results, for experience and credence goods characterized by greater quality uncertainty. However, this adverse selection is present only in the market for experience and credence goods and is non-existent in markets for search goods. Adverse selection in the case of experience and credence goods presents a significant problem for consumers, regulators, as well as the sponsored search intermediaries. Product categories which lack adequate quality information (and for which it is costly to ascertain quality) are the ones where lower quality firms bid higher and appear on the top of the search results listings. This could adversely affect

consumer welfare particularly for uninformed consumers and consumers who trust the search results provided by these search engines.

However, with informed consumers, or with better signaling and reputation mechanisms this bidding behavior (low quality firms bidding higher) is unlikely to prevail in the long-run. The fact that there is greater entry and exit of advertisers (bidders) in product categories with greater uncertainty (credence goods, in particular) also suggests that there is a greater turnover of bidders in this category and highlights the lack of reputation effects. The nascency of online sponsored search markets could be another factor that facilitates adverse selection. In the case of search goods, where there is less quality uncertainty, we do not find any significant distortion or bias in the search listings.

These findings are particularly relevant for the providers of search services, as search listings that are biased can reduce consumer welfare and eventually the profitability of the intermediary as well as drive out higher quality firms. Our findings suggest that search service providers would do well to incorporate reputation mechanisms and additional signals of quality (such as user reviews) in their search listings. Thus, search results that are weighted both by the bids and quality signals (as in the case of Google) can help alleviate some of adverse selection problems prevalent in product markets with higher inherent uncertainty.

While this is a potential problem for firms, intermediaries, and consumers, it is also possible that sponsored search mechanisms in fact enable lesser known firms (and new entrants) to bid higher and reach out to more consumers by bidding appropriately online. Thus, it would be important to differentiate between firms that sell low-quality products, and those that tend to be classified as low-quality due to the lack of adequate quality signals (traffic, inlinks, etc.). While the former can adversely affect welfare, the latter could actually improve social welfare.

Finally, it is clear that market forces act differently for different product categories. The dynamics of bidding strategies by firms are not only indicative of the significance of sponsored search auctions for these firms, but also can provide interesting insights into the competitive landscape within product categories/keywords. A more extensive analysis of such bidding dynamics promises to shed light on relative competition across different product categories as well as the existence of strategic groups within product categories.

6. FUTURE RESEARCH AND CONCLUSIONS

Sponsored search auctions for keywords, though growing rapidly, is still in its infancy. Despite the nascency of sponsored search/advertising mechanisms, there exist significant differences between traditional advertising formats and sponsored search formats. Of particular interest is the fact that sponsored search is a *performance-based* advertising model where firms pay only when consumers click on the links to their websites. Thus the cost incurred by firms/bidders is more closely linked to their revenues from potential sales to online consumers⁹. In comparison, advertising in traditional print/broadcast media is characterized by fixed costs and further removed from any potential sales. Thus the two advertising formats (traditional vs. sponsored search) differ in the risk to advertisers. Firms bidding high in sponsored search auctions face a much lower risk of losing their investment, as they pay only for when consumers click on their links. Future research should examine the implications of these different cost structures on the incentives for (low vs. high quality) firms to advertise. It would also be useful to analyze bidding dynamics of sellers across search engines. Specifically, do we find that the same bidders rank higher in the search results across various sponsored search outlets, such as general search engines and shopping search engines?

⁹ Typically search engines also charge a small setup fee, and a minimum monthly fee (\$50 and \$20 at Overture respectively).

Future studies can also examine consumer behavior in response to the sponsored search phenomena. Laboratory studies designed to analyze the differential search strategies adopted by consumers would help understand how consumer search across different search formats. Studies of this nature are sparse, given the recency of the phenomenon. However, without an understanding of consumers' reactions to the different kinds of search and advertising mechanisms, we can only infer their behavior in online settings from prior studies in traditional channels. Whether these results translate well to the online world is an empirical question yet to be answered.

Table 1. Classification of goods and services as per SEC framework

Search	Experience	Credence
CDs	Flowers	Therapy
Books	Automobiles	Psychics
PDA	Auto insurance	Relationships
PC	Healthcare	Used cars
laptop	Pest control	Vacation
Cell phones	Home security systems	Cosmetic surgery
Flight tickets	Cruises	Tax services
Refrigerators	Jewelers	Counseling
Scanners	Martial arts	Immigration
Television	Moving n storage	Attorney
Toys	Perfumes	
Apparel	Photographers	
	Brokerage	
	Event planning	

Table 2. Summary of measures used in the study

Measure	How is it calculated?	Scale
SEARCH	Dummies for search, experience and credence goods	Binary
EXPERI		
CREDEN		
LNTRFFIC	Overall traffic rank is a combination of historical page view rank (per million) and page reach (% of all Internet users). This variable is log-transformed	Continuous Reverse coded (Less is better)
UFIRMS	Unique number of firms bidding within the sample period for a particular keyword.	
NPOSITION	POSITION / UFIRMS	
POSITION	The position of the firm in the first 20 ranks based on average rank during the sample period	1 to 20 (less is better)
LNAVGBID	The average bid placed by the firm over the period that bid data was collected for, excluding days it did not bid. This variable is log-transformed	Min \$0.05 Continuous
LNBDDEV	The standard deviation of the percentage bid differences between two consecutive days (i.e. BIDDIFF) over the period that bid data was collected for, excluding days it did not bid. This variable is log-transformed	Continuous
BIDDIFF	$[(\text{Bid on day } t) - (\text{Bid on day } t-1)] / (\text{Bid on day } t-1)$	
LNRNKDEV	The standard deviation of the percentage rank differences between two consecutive days (i.e. RNKDIFF) over the period that bid data was collected for, excluding days it did not bid. This variable is log-transformed.	Continuous
RNKDIFF	$[(\text{Rank on day } t) - (\text{Rank on day } t-1)] / (\text{Bid on day } t-1)$	
SEARCH*LNTRRFIC	The product of SEARCH and LNTRRFIC	
EXPERI*LNTRRFIC	The product of EXPERI and LNTRRFIC	
CREDEN*LNTRRFIC	The product of CREDEN and LNTRRFIC	
SEARCH*NPOSITION	The product of SEARCH and POSITION	
EXPERI* NPOSITION	The product of EXPERI and POSITION	
CREDEN* NPOSITION	The product of CREDEN and POSITION	

Table 3. Correlations among variables used in analysis

Variables	UFIRMS	NPOSITION	AVGBID	AVBIDDEV	AVRNKDV	TRAFFICR
UFIRMS	1.00					
NPOSITION	-0.55***	1.00				
AVGBID	0.46***	-0.64***	1.00			
AVBIDDEV	0.22***	-0.27***	0.36***	1.00		
AVRNKDEV	0.24***	-0.47***	0.44***	0.67***	1.00	
TRAFFICR	-0.0024	0.0268	0.0737*	-0.15***	-0.17***	1.00
SEARCH	-0.14***	0.0296	-0.30***	0.0342	-0.0342	-0.27***
EXPERI	0.21***	-0.088**	0.33***	0.0230	0.0138	0.20***
CREDENCE	-0.08**	0.0672*	-0.0559	-0.0604	0.0200	0.0608

*** sig at 0.01 level ** sig at .05 level * sig at .10 level

Table 4. Regression analyses

	LNAVGBID Model 1a	LNAVGBID Model 1b	LNBIDEV Model 2a	LNBIDEV Model 2b	LNRKDEV Model 3a	LNRKDEV Model 3b	LNTRFFIC Model 4a	LNTRFFIC Model 4b
LNBIDEV					0.354*** (.025)	0.354*** (.025)		
LNAVGBID			0.711*** (.099)	0.711*** (.099)	0.083* (.043)	0.083* (.043)		
NPOSITION	-0.566*** (.023)	-0.566*** (.023)	0.005 (.075)	0.005 (.075)	-0.255*** (.033)	-0.255*** (.033)	0.159 (.126)	0.159 (.126)
SEARCH		-0.319*** (.028)		0.200*** (.067)		-0.029 (.036)		-1.000*** (.136)
EXPERI	0.341*** (.030)		-0.214*** (.072)		0.031 (.038)		1.072*** (.145)	
CREDEN	0.174*** (.023)	-0.136*** (.028)	-0.139** (.067)	0.056** (.064)	0.093*** (.031)	0.065** (.031)	0.764*** (.147)	-0.210 (.138)
LNTRFFIC	-0.001 (.026)	-0.001 (.026)	-0.243*** (.059)	-0.243*** (.059)	-0.098*** (.030)	-0.098*** (.030)		
SEARCH* LNTRFFIC		-0.025 (.030)		-0.067 (.066)		0.031 (.035)		
EXPERI* LNTRFFIC	0.027 (.032)		0.072 (.070)		-0.033 (.037)			
CREDEN* LNTRFFICR	0.034* (.020)	0.010 (.028)	0.072 (.064)	0.006 (.063)	0.007 (.026)	0.037 (.032)		
SEARCH* NPOSITION				-0.045 (.064)		0.015 (.027)		0.216 (.143)
EXPERI* NPOSITION			0.049 (.069)		-0.017 (.029)		-0.231 (.153)	
CREDEN* NPOSITION			0.007 (.056)	-0.036 (.048)	-0.003 (.024)	0.012 (.024)	-0.279* (.146)	-0.069 (.133)
F-statistic	F(6, 655)= 113.00***	F(6, 655)= 113.00***	F(8, 653)= 79.92***	F(9, 652)= 20.39***	F(10, 651)= 78.01***	F(10, 651)= 78.01***	F(5, 658)= 12.36	F(5, 658)= 12.36
R ²	0.506	0.506	0.556	0.183	0.556	0.556	0.086	0.086
N, total df	662	662	662	662	662	662	664	664
Robust	Yes	Yes	Yes	Yes	Yes	Yes	No	No

*** sig at 0.01 level ** sig at .05 level * sig at .10 level

standard error in parentheses

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