
An Empirical Analysis of Sponsored Search Performance in Search Engine Advertising

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- Background
- Research Question and Summary of Results
- Theory and Econometric Model
- Data
- Results
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- Future and Ongoing Work

Search Engine Marketing

- Search engines act as intermediaries between advertisers and users.
- Refer consumers to advertisers based on user-generated queries and keyword advertisements.
- Consumer behavior from search to purchase:
 - Search->Impressions -> Clicks ->Conversions

Search Engine Marketing

- Pay per click (PPC) is where advertisers only pay when a user actually clicks on its ad listing to visit its website.
- Keyword: "Used cars San Diego"

The screenshot shows a Google search results page for the query "used cars san diego". The search bar at the top contains the text "used cars san diego" and a "Search" button. Below the search bar, the results are categorized into "Sponsored Links" and "Web".

Sponsored Links:

- San Diego Used Autos** (www.automotiveadslatinc.com) - Nissan, Ford, GM, VW's, Jeep, Hyundai, Honda, Acura and more!
- San Diego Used Cars** (SD-Used-Cars.com) - Search Online Used Car Inventory San Diego, CA Used Cars and Trucks
- Mile of Cars - San Diego** (www.mileofcars.com) - 21 car dealerships with more than 5,000 cars. Find the one for you.
- Mossy San Diego** - View our Huge Inventory of New and Used Cars, Trucks & SUV's www.MossyUsedCars.com
- San Diego Used Cars** - Fast No-Obligation Internet Price! San Diego Used Cars BobBaker.com
- Honda Certified Used Cars** - Everything you expect from Honda. See local Honda inventory & prices. honda.googlepages.com
- Used Cheap Cars** - Thousands of cars under \$5,000. Search by Price - It's Fast & Easy! www.AutoMart.com
- Used Ford - San Diego CA** - Best Location & Price 800-790-6815! San Diego Used Cars BobBakerFord.net San Diego, CA
- Used Cars** - Find A Car In Your Area.

Web: Results 1 - 10 of about 4,340,000 for used cars san diego. (0.13 seconds)

Find results for used cars san diego in Vehicles search

Location: san diego Condition: used [Go]

Remember this location

San Diego Used Cars - Auto Classifieds - Used Auto and Car Trader
San Diego Used Cars - Auto Classifieds - Used Auto and Car Trader Place your Auto Classified Ad at UsedCarsDB.com and reach out to millions.
sandiego.setmycar.com/ - 47k - Cached - Similar pages - Note this

Used Cars San Diego
We sell high quality used cars in San Diego California. We offer many makes and models of used vehicles.
www.carsandiego.com/ - 14k - Cached - Similar pages - Note this

Find San Diego, California Used Cars On Yahoo! Autos
Yahoo! Autos used cars in San Diego, California - find used car prices, pictures, options and features. Find the best deal and respond to the listings ...
autos.yahoo.com/used-cars/california-s-san_diego.html - 13k - Cached - Similar pages - Note this

Characteristics of Keywords

Classification of user queries in search engines (Broder 2002)

- Navigational
- Transactional
- Informational

Prior theory to motivate study using keyword attributes

- Presence of Retailer information (Retailer name)
 - “K-Mart bedding”
- Presence of Brand information (Manufacturer/Product specific brand)
 - “Nautica bedsheets”
- Specific search or Broad search (Length of keyword in words)
 - “Cotton bedsheets” vs. “300 count Egyptian cotton bedsheets”.

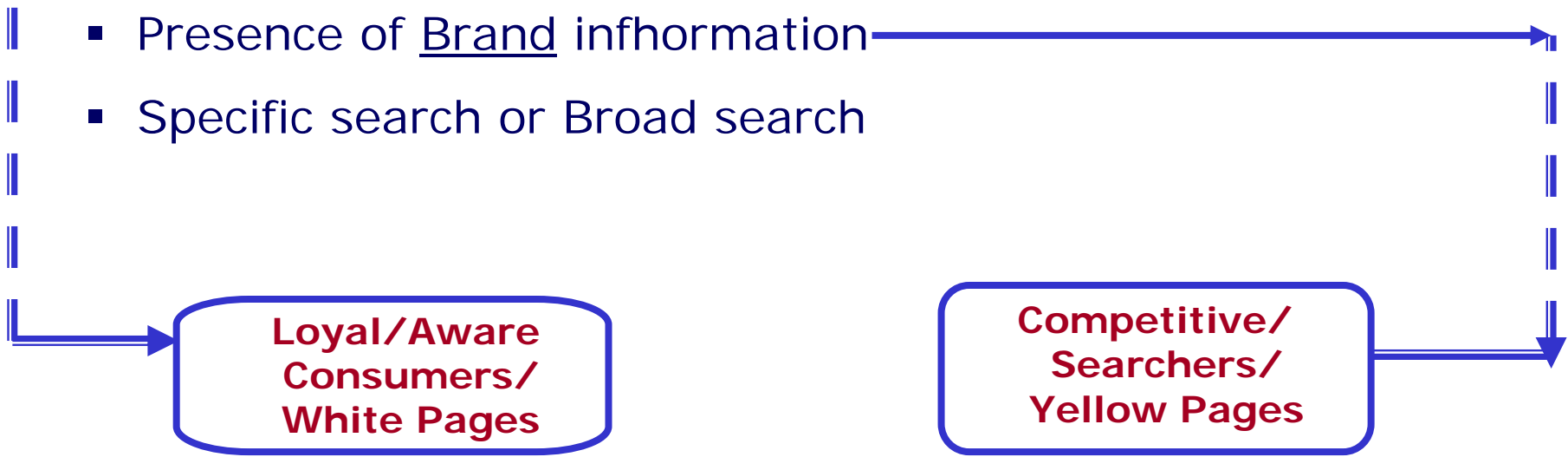
Implications?

Prior theory to motivate study using keyword attributes

- Presence of Retailer information
- Presence of Brand information
- Specific search or Broad search

Loyal/Aware
Consumers/
White Pages

Competitive/
Searchers/
Yellow Pages



Research Agenda

Paid Search Advertising

How does sponsored search advertising affect consumer behavior on the Internet?

- What attributes of a sponsored advertisement influences users' click-through and conversion rates?
- How do the “keyword attributes” influence the advertiser's cost-per-click, and the search engine's ranking decision?
- Policy simulations to impute optimal CPC for the advertiser

Summary of Findings and Contributions

- ***Hierarchical Bayesian model to empirically estimate the impact of various keyword attributes (Wordographics).***
 - Retailer information increases CTR.
 - Brand information increases conversion rates.
 - Increases in keyword length decreases CTR.
 - Increase in Rank decreases both CTR and conversion rates.
- ***Also analyze the impact of these covariates on firm level decisions – `CPC' and `Rank'.***
 - Policy simulations suggest that the advertiser can make improvements in its expected profits from optimizing its CPC.
 - Search engines take into account both the bid price as well as prior CTR before setting the final rank of an advertisement.

Empirical Methodology

Framework

- Hierarchical Bayesian model
 - Rossi and Allenby (2003)
- Markov Chain Monte Carlo methods
 - Metropolis-Hastings algorithm with a random walk chain to generate draws (Chib and Greenberg 1995)

Models of Decision Making

- Consumer level decision: Click-through
- Consumer level decision: Conversion
- Advertiser decision: Cost-per-click
- Search Engine decision: Keyword Rank

N= number of impressions
n = number of clicks
m= number of conversions
p = probability of click-through
q = probability of conversion conditional on click-through

- First, a user clicked and made a purchase. The probability of such an event is $p_{ij}q_{ij}$.
- Second, a user clicked but did not make a purchase. The probability of such an event is $p_{ij}(1-q_{ij})$.
- Third, an impression did not lead to a click-through. The probability of such an event is $1 - p_{ij}$.
- Then, the probability of observing (n_{ij}, m_{ij}) is given by:

$$f(n_{ij}, m_{ij}, p_{ij}, q_{ij}) = \frac{N_{ij}!}{m_{ij}!(n_{ij} - m_{ij})!(N_{ij} - n_{ij})!} \{p_{ij}q_{ij}\}^{m_{ij}} \{p_{ij}(1 - q_{ij})\}^{n_{ij} - m_{ij}} \{1 - p_{ij}\}^{N_{ij} - n_{ij}}$$

Empirical Models

$$p_{ij} = \frac{\exp(\beta_{i0} + \beta_{i1} \text{Rank}_{ij} + \alpha_1 \text{Retailer}_i + \alpha_2 \text{Brand}_i + \alpha_3 \text{Length}_i + \varepsilon_{ij})}{1 + \exp(\beta_{i0} + \beta_{i1} \text{Rank}_{ij} + \alpha_1 \text{Retailer}_i + \alpha_2 \text{Brand}_i + \alpha_3 \text{Length}_i + \varepsilon_{ij})}$$

$$q_{ij} = \frac{\exp(\theta_{i0} + \theta_{i1} \text{Rank}_{ij} + \bar{\theta}_2 \text{CTR}_{ij} + \delta_1 \text{Retailer}_i + \delta_2 \text{Brand}_i + \delta_3 \text{Length}_i + \eta_{ij})}{1 + \exp(\theta_{i0} + \theta_{i1} \text{Rank}_{ij} + \bar{\theta}_2 \text{CTR}_{ij} + \delta_1 \text{Retailer}_i + \delta_2 \text{Brand}_i + \delta_3 \text{Length}_i + \eta_{ij})}$$

Consumer
Decision

$$\ln(\text{CPC}_{ij}) = \omega_{i0} + \omega_{i1} \text{Rank}_{i,j-1} + \omega_{i2} \text{Profit}_{i,j-1} + \lambda_1 \text{Retailer}_i + \lambda_2 \text{Brand}_i + \lambda_3 \text{Length}_i + \mu_{ij}$$

Advertiser
Decision

$$\ln(\text{Rank}_{ij}) = \phi_{i0} + \phi_{i1} \text{Bid Price}_{i,j} + \bar{\phi}_2 \text{CTR}_{i,j-1} + \tau_1 \text{Retailer}_i + \tau_2 \text{Brand}_i + \tau_3 \text{Length}_i + \nu_{ij}$$

Search
Engine
Decision

Data

- Large nationwide retailer (Fortune-500 firm) with 520 stores in the US and Canada.
- 3 months dataset from January 07 to March 07 on Google Adwords advertisements (Also data on Yahoo and MSN).
- 1800 unique keyword advertisements on a variety of products.
- **Keyword level (Paid Search):** Number of impressions, clicks, Cost per click (CPC), Rank of the keyword, Number of conversions, Revenues from a conversion, quantity and price in each order.
- **Product Level:** Quantity, Category, Price, Popularity.
- These are clustered into six product categories
 - Bath, bedding, electrical appliances, home décor, kitchen and dining.

Results

Table 2: Coefficient Estimates on Click-through

	<i>Intercept</i>	<i>Retailer</i>	<i>Brand</i>	<i>Length</i>
	$\bar{\beta}_0$	α_1	α_2	α_3
Intercept	-2.062 (0.050)	2.031 (0.155)	-0.105 (0.090)	-0.109 (0.049)
	$\bar{\beta}_1$	γ_1	γ_2	γ_3
Rank	-0.251 (0.013)	-0.251 (0.061)	-0.056 (0.022)	-0.002 (0.014)

Table 3: Coefficient Estimates on Conversion

	<i>Intercept</i>	<i>Retailer</i>	<i>Brand</i>	<i>Length</i>
	$\bar{\theta}_0$	δ_1	δ_2	δ_3
Intercept	-4.812 (0.213)	-0.481 (0.339)	0.469 (0.138)	-0.130 (0.074)
	$\bar{\theta}_1$	κ_1	κ_2	κ_3
Rank	-0.099 (0.031)	0.293 (0.106)	0.049 (0.035)	0.037 (0.031)
	$\bar{\theta}_2$			
CTR	0.822 (0.368)			

- Retailer-specific information increases CTR by 26.16%
- Brand-specific information increases conversion rates by 23.76%
- Increase in rank decreases both CTR and conversion rates

Results

	<i>Intercept</i>	<i>Retailer</i>	<i>Brand</i>	<i>Length</i>
	$\bar{\omega}_0$	λ_1	λ_2	λ_3
Intercept	-1.285 (0.020)	-1.036 (0.089)	-0.171 (0.043)	0.095 (0.027)
	$\bar{\omega}_1$	ρ_{11}	ρ_{12}	ρ_{13}
LagRank	-0.027 (0.006)	0.110 (0.039)	0.013 (0.013)	-0.003 (0.008)
	$\bar{\omega}_2$	ρ_{21}	ρ_{22}	ρ_{23}
LagProfit	-0.020 (0.008)	-0.049 (0.033)	-0.005 (0.022)	0.003 (0.013)

Table 4: Coefficient Estimates on Bid Prices

	<i>Intercept</i>	<i>Retailer</i>	<i>Brand</i>	<i>Length</i>
	$\bar{\phi}_0$	τ_1	τ_2	τ_3
Intercept	2.119 (0.123)	-0.636 (0.152)	-0.434 (0.076)	-0.109 (0.044)
	$\bar{\phi}_1$	π_1	π_2	π_3
Bid Price	-3.025 (0.353)	1.787 (0.390)	0.307 (0.179)	0.455 (0.124)
	$\bar{\phi}_2$			
CTR	-1.328 (0.080)			

Table 5: Coefficient Estimates on Keyword Ranks

Policy Simulations

Overview

- Determine optimal bid price
- Impute profits with optimal bid and actual CPC

Findings

- Differences between optimal bid and actual CPC
 - Average deviation is 24 cents per bid
 - Generally CPC higher than optimal bid price (94%)
- Differences in 'Expected Profits' and 'Actual Profits' per keyword
 - Regressions with optimal prices show that firm should *increase* bid price with **Retailer** or **Brand** information, and decrease with **Length**.

Some Limitations

- No data on Competition.
- No explicit data on landing page quality score.
 - Content analysis based on metrics on Google Adwords (but noisy?)
- No data on text of the ad copy

Takeaways

- ***Empirically estimate the impact of various keyword attributes on consumers' search and purchase propensities.***
 - Retailer-specific information increases CTR and brand-specific information increases conversion rates.
 - Increase in Rank decreases both CTR and conversion rates.
 - What are the most “attractive” keywords from an advertiser’s perspective?
 - Implications for products of interest to “loyal consumers” versus “shoppers/searchers”.

Takeaways

- ***Analyze the impact of these covariates on advertiser and search engine decisions such as CPC and Rank.***
 - Evidence that while the advertiser is exhibiting some naïve learning behavior they are not bidding optimally.
 - How should it bid in search engine advertising campaigns to maximize profits?