An Empirical Analysis of Sponsored Search Performance in Search Engine Advertising

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Outline

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

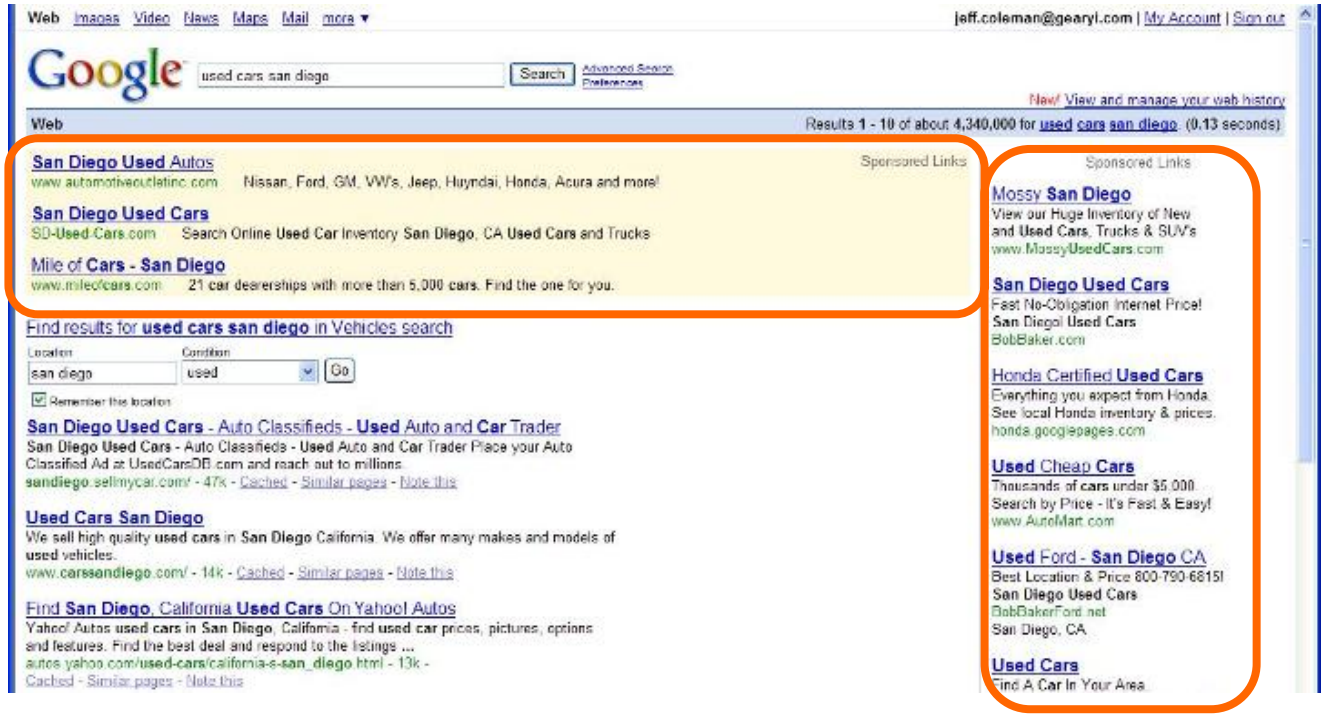
Search Engine Marketing

- 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”



Characteristics of Keywords

Classification of user queries in search engines (Broder 2002)

- Navigational
- Transactional
- Informational

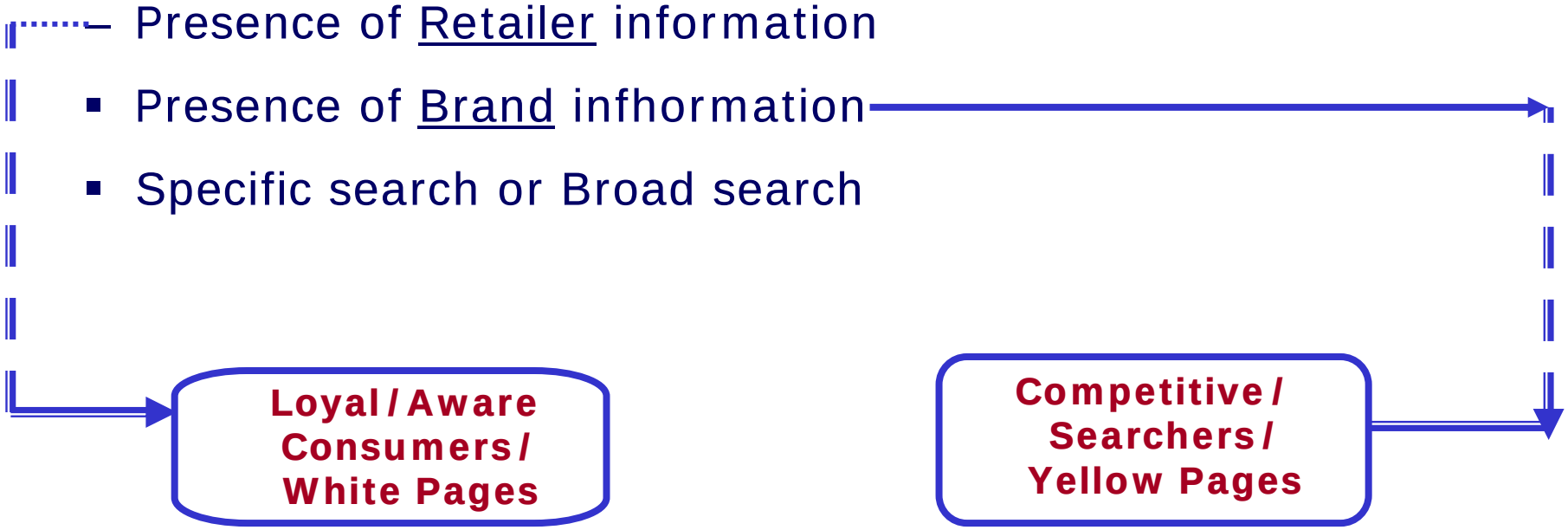
Prior theory to motivate study using keyword attributes

- 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 infhormation
- Specific search or Broad search



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

Model

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

$$p_{ij} = \frac{\exp(\beta_{i0} + \beta_{i1} Rank_{ij} + \alpha_1 Retailer_i + \alpha_2 Brand_i + \alpha_3 Length_i + \varepsilon_{ij})}{1 + \exp(\beta_{i0} + \beta_{i1} Rank_{ij} + \alpha_1 Retailer_i + \alpha_2 Brand_i + \alpha_3 Length_i + \varepsilon_{ij})}$$

$$q_{ij} = \frac{\exp(\theta_{i0} + \theta_{i1} Rank_{ij} + \overline{\theta_2} CTR_{ij} + \delta_1 Retailer_i + \delta_2 Brand_i + \delta_3 Length_i + \eta_{ij})}{1 + \exp(\theta_{i0} + \theta_{i1} Rank_{ij} + \overline{\theta_2} CTR_{ij} + \delta_1 Retailer_i + \delta_2 Brand_i + \delta_3 Length_i + \eta_{ij})}$$

Consumer Decision

$$\ln(CPC_{ij}) = \omega_{i0} + \omega_{i1} Rank_{i,j-1} + \omega_{i2} Profit_{i,j-1} + \lambda_1 Retailer_i + \lambda_2 Brand_i + \lambda_3 Length_i + \mu_{ij}$$

Advertiser Decision

$$ln(Rank_{ij}) = \phi_{i0} + \phi_{i1} Bid\ Price_{i,j} + \overline{\phi_2} CTR_{i,j-1} + \tau_1 Retailer_i + \tau_2 Brand_i + \tau_3 Length_i + \nu_{ij}$$

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

	Intercept	*Retailer*	*Brand*	*Length*
	$\overline{\beta_0}$	α_1	α_2	α_3
Intercept	**-2.062**	**2.031**	-0.105	**-0.109**
	(0.050)	**(0.155)**	(0.090)	**(0.049)**
	$\overline{\beta_1}$	γ_1	γ_2	γ_3
Rank	**-0.251**	**-0.251**	**-0.056**	-0.002
	(0.013)	**(0.061)**	**(0.022)**	(0.014)

Table 3: Coefficient Estimates on Conversion

	Intercept	*Retailer*	*Brand*	*Length*
	$\overline{\theta_0}$	δ_1	δ_2	δ_3
Intercept	**-4.812**	-0.481	**0.469**	-0.130
	(0.213)	(0.339)	**(0.138)**	(0.074)
	$\overline{\theta_1}$	κ_1	κ_2	κ_3
Rank	**-0.099**	**0.293**	0.049	0.037
	(0.031)	**(0.106)**	(0.035)	(0.031)
	$\overline{\theta_2}$			
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

	Intercept	*Retailer*	*Brand*	*Length*
	$\overline{\omega_0}$	λ_1	λ_2	λ_3
Intercept	**-1.285**	**-1.036**	**-0.171**	**0.095**
	(0.020)	**(0.089)**	**(0.043)**	**(0.027)**
	$\overline{\omega_1}$	ρ_{11}	ρ_{12}	ρ_{13}
LagRank	**-0.027**	**0.110**	0.013	-0.003
	(0.006)	**(0.039)**	(0.013)	(0.008)
	ω_2	ρ_{21}	ρ_{22}	ρ_{23}
LagProfit	**-0.020**	-0.049	-0.005	0.003
	(0.008)	(0.033)	(0.022)	(0.013)

Table 4: Coefficient Estimates on Bid Prices

	Intercept	*Retailer*	*Brand*	*Length*
	$\overline{\phi_0}$	τ_1	τ_2	τ_3
Intercept	**2.119**	**-0.636**	**-0.434**	**-0.109**
	(0.123)	**(0.152)**	**(0.076)**	**(0.044)**
	$\overline{\phi_1}$	π_1	π_2	π_3
Bid Price	**-3.025**	**1.787**	0.307	**0.455**
	(0.353)	**(0.390)**	(0.179)	**(0.124)**
	ϕ_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?