Reserve Prices in Internet Advertising Auctions: A Field Experiment

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Outline

- Introduction
- Theory
- Experiment
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Outline

Introduction

- Motivation:
  - observed reserve prices are substantially lower than the theoretically optimal ones
- Research question:
  - Can sellers use reserve prices to substantially raise revenues?
- Contributions:
  - large-scale "sponsored search" auctions field experiment
  - reserve prices in auctions can play a role in raising revenues

Sponsored Search Auctions

- Internet users get matched sponsored links (eg: Google Ads) after searching for some keywords
- The advertiser pays the search engine if users click the sponsored link to its Web page
- Different positions of an ad have different desirability for advertisers
- "Generalized second-price" (GSP) auction
  - advertiser with ad position i pays the bid of the advertiser in position $i+1$
  - equivalent to standard second-price auction if one ad position per result page
  - GSP generally does not have an equilibrium in dominant strategies
  - truth-telling is not an equilibrium of GSP

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Theory

- Assumptions:
  - assume that the virtual valuation is an increasing function
  - assume that bidders are symmetric
- GSP with reserve price $r^*$is a revenue-maximizing mechanism
  - bidders with values less than r^*will receive no clicks
  - among the bidders with values greater than r^*, the ones with higher values will receive higher positions

The Impact of Reserve Prices on Revenues

- In single-object auctions, reserve prices only play an important role if the number of bidders is small.
  - intuition: reserve price r only has a positive impact when one bidder's realized value is above r and the other bidders' values are all below r, and the probability of this event becomes small as the number of bidders increases
- However, in multi-unit auctions, reserve prices retain their power for much higher number of bidders.
  - intuition: when positions are enough for bidders, without reserve price, the auctioneer's revenue would be zero

Lognormal Distribution Assumption

Table 2: The impact of optimal reserve prices, lognormal distribution

Bidders	$r = 0$	$r = 0.10$	$r = 0.235$	$r = 0.37$
$n = 2$	0.08	0.22	0.32	0.34
	24%	63%	93%	100%
$n = 6$	0.68	0.78	0.87	0.91
	75%	86%	96%	100%
$n = 10$	1.24	1.28	1.33	1.36
	91%	94%	98%	100%

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Simplifications for Estimation

- Each ad's probability of being clicked is the same and the ads are ranked solely bosed on bids.
- The same "click-through rate (CTR) curve" was used for all keywords.
- The values that advertisers assigned to clicks did not depend on where on the screen the ads were shown or on which or how many other ads appeared on the screen.
- The bids of the advertisers on a keyword reflect only their value of a click from this keyword and the balues of other advertisers bidding for that same keyword
- The "theoretical optimality" of the computed reserve prices ignores the dynamic aspects of the real-world
- cannot claim consistency but can be viewed as sufficiently robust

Full Sample Results

Table 4: Full sample

Variable	Value	t-statistic	p-value
Number of keywords (T - treatment group)	438,632		
Number of keywords (C - control group)	23,016		
(Mean change in depth in T)−(mean change in depth in C)	−0.9125	−80.53	< 0.0001
(Mean change in revenue in T)−(mean change in revenue in C)	12.85%	1.69	0.0915
Estimated impact of reserve prices on revenues	2.71%	4.73	< 0.0001

Results by Search Volume

Table 5: Restricted sample (keywords with fewer than 10 searches per day)

Variable	Value	*t*-statistic	*p*-value
Number of keywords (T – treatment group)	382,860		
Number of keywords (C – control group)	20,133		
(Mean change in depth in T)–(mean change in depth in C)	–0.9039	–75.53	< 0.0001
(Mean change in revenue in T)–(mean change in revenue in C)	10.33%	1.19	0.2354
Estimated impact of reserve prices on revenues	–2.19%	–2.36	0.0183

Table 6: Restricted sample (keywords with at least 10 searches per day)

Variable	Value	*t*-statistic	*p*-value
Number of keywords (T – treatment group)	55,772		
Number of keywords (C – control group)	2,883		
(Mean change in depth in T)–(mean change in depth in C)	–0.971	–28.07	< 0.0001
(Mean change in revenue in T)–(mean change in revenue in C)	14.03%	1.51	0.1316
Estimated impact of reserve prices on revenues	3.30%	2.32	0.0201

Experimental Results by Reserve Price Level

Table 7: Restricted sample (optimal reserve price $< 20¢$)

Variable	Value	t-statistic	p-value
Number of keywords (T – treatment group)	222,249		
Number of keywords (C – control group)	11,615		
(Mean change in depth in T)–(mean change in depth in C)	–0.8612	–60.29	< 0.0001
(Mean change in revenue in T)–(mean change in revenue in C)	–11.88%	–2.45	0.0144
Estimated impact of reserve prices on revenues	–9.19%	–11.1	< 0.0001

Table 8: Restricted sample (optimal reserve price $\geq 20¢$)

Variable	Value	t-statistic	p-value
Number of keywords (T – treatment group)	216,383		
Number of keywords (C – control group)	11,401		
(Mean change in depth in T)–(mean change in depth in C)	–0.9664	–55.09	< 0.0001
(Mean change in revenue in T)–(mean change in revenue in C)	14.59%	1.79	0.0736
Estimated impact of reserve prices on revenues	3.80%	5.41	< 0.0001

Experimental Results by Number of Advertisers

Table 9: Restricted sample (average depth < 5.5)

Variable	Value	t-statistic	p-value
Number of keywords (T – treatment group)	217,087		
Number of keywords (C – control group)	11,205		
(Mean change in depth in T)–(mean change in depth in C)	–0.9332	–77.66	< 0.0001
(Mean change in revenue in T)–(mean change in revenue in C)	25.50%	1.58	0.1142
Estimated impact of reserve prices on revenues	10.06%	7.29	< 0.0001

Table 10: Restricted sample (average depth ≥ 5.5)

Variable	Value	t-statistic	p-value
Number of keywords (T – treatment group)	221,545		
Number of keywords (C – control group)	11,811		
(Mean change in depth in T)–(mean change in depth in C)	–0.9113	–52.93	< 0.0001
(Mean change in revenue in T)–(mean change in revenue in C)	10.44%	1.25	0.2102
Estimated impact of reserve prices on revenues	2.54%	3.59	< 0.0003

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Conclusion

- Setting appropriate reserve prices can lead to substantial increases in auction revenues.
- The theory of optimal auction design is directly applicable in practice.