

ADVERSE SELECTION AND AUCTION DESIGN FOR INTERNET DISPLAY ADVERTISING

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Old Advertisers & New

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

- John Wanamaker, Advertising pioneer

Old-Fashioned “Brand” Ads

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MIAMI CITY EDITION Program TV DON QUIXOTE APRIL 11TH 4:30PM CENTER CLICK TO EXPAND

Customer Service Digital Newspaper el Nuevo Herald Classifieds Jobs Cars Real Estate Find & Save Deals Public Notices Place an Ad

Miami Herald

MIAMI HERALD HOME DELIVERY JUST 53¢ A DAY!

FREE SHIPPING DEALS Shop with us today and enjoy great deals everyday Store Locations BrandMart U.S.A.

Home News Sports Business Lifestyle Entertainment Opinion Obituaries Subscriptions 83°

HIGHLIGHTS

DEADLINE MIAMI

The link to news happening now

- 2 teens in crash, good Samaritan killed after another car plows into them
- Man accused of kicking feces-covered dog in face
- Police-involved shooting at nightclub near airport

Miami Heat

Wade returns to lineup, but Miami Heat loses to Hawks

- Le Batard: Family plan is a huge success for Pat Riley, Heat

Columns

Grimm: Zombie Apocalypse bill

- Hlaasen: First, do no harm — to your bank account
- Pitts: About that missing plane: Give it a rest!

PASSOVER

Jews come together to retell the story of Passover



As Jews retell an ancient story of freedom and share an traditional meal on Monday and Tuesday nights, many have taken to heart a growing Passover tradition in South Florida: Everyone should have a place to go. - 8:56 AM ET

- Davie citrus family preserves Passover traditions
- Cooking for Passover gets creative at local synagogues

THE EVERGLADES

Fishing heals war vets' unseen wounds

A veteran and an angler's fishing trips serve as a form of therapy from the stresses of military combat and coming home. - 8:56 AM ET

- Fishing as healing

BREAKING NEWS

- Stabbing suspect at nightclub shot by Miami-Dade officer - Updated 6 minutes ago
- Bus hits truck on Mexico highway; 36 reported dead - Updated 8 minutes ago
- 9/11 defendant's competency is focus of Guantánamo hearings - Updated 28 minutes ago
- Summer teasers, zany honors at MTV Movie Awards - Updated 28 minutes ago
- 2 teens in crash, good Samaritan killed when car hits them - 11:11 AM ET

» More

COMMUNITY NEWS

Select your community

KEY BISCAIYNE

Key Biscayne to spend \$80,000 on traffic study under no-bid contract

PINECREST

Pinecrest may limit 'McMansions'

HIALEAH

Homeowners in Hialeah neighborhoods live on crumbling streets

SCHOOLS

In Miami, an 'F' school strives to make the grade

On Monday students at

South MOTORS

OIL & WASH starting from only \$24.95*

*Conventional oil. Factory filter. Outside wash and vacuum. Pricing varies by model.

MIAMI'S NEW CENTER

Brickell Heights

SOURCELY EQUINOX RELATE

BRICKELLHEIGHTS.COM 786.623.5719

Get the Deal! Boat rental (seats up to 6) --

New-Fashioned “Performance” Ads

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The screenshot displays the United MileagePlus website interface, featuring several performance-oriented advertisements. The main navigation bar includes tabs for Flight, Hotel, Car, and Vacation. The Flight section is active, showing search options for Round Trip, One Way, and Multiple Destinations. Below this, there are input fields for From and To locations, departure and return dates, and cabin class. A search button is prominently displayed. To the right, a banner for RewardsPlus highlights the benefits of accumulating more points and miles. Below the banner, there are links for Latest News and Offers, and a section for MileagePlus Sign In. The sign-in section includes fields for MileagePlus number and PIN/Password, along with links for Remember Me, Forgot PIN?, and Sign In. A link for Not a member? Join Now is also present. Below the sign-in section, there is a promotion for the United MileagePlus Explorer Business Card, offering 30,000 Bonus Miles. At the bottom, there are three more ads: a Cruise Reservations ad, a social network ad for United, and a GE Capital Retail Bank ad for a high-yield savings account. An orange circle highlights the social network ad and the GE Capital Retail Bank ad.

Flight Hotel Car Vacation

Round Trip One Way Multiple Destinations

From: (city or airport) To: (city or airport)

Search Nearby Airports

Find Lower Fare +/- 3 Days

Search Specific Dates My Dates are Flexible

Depart Date: Time: Anytime

Return Date: Time: Anytime

Adults: 1 Children

Offer Code (optional):

Cabin: Economy

Search By: Price Schedule Award Travel

Nonstop Flights Only

Advanced Search Search

Children, Country of Purchase...

Enroll in MileagePlus®. Learn More

Cruise Reservations

More points. More miles. Make your travel more rewarding with RewardsPlus.

Learn more MileagePlus UNITED Marriott REWARDS.

Fisherman's Reef & Morning Star Marriott Beach Resort

Latest News and Offers Changed bag rules and optional services Important notices 2014 MileagePlus Premier® program MileagePlus & Marriott create RewardsPlus

Print Boarding Pass Check Flight Status

Confirmation or MileagePlus Number: Go

More Check-in options Check-in is available within 24 hours of departure

Change or View Reservations See More

Find a Reservation by Confirmation Number

Reservation Type: Flight Car

Confirmation: Last Name: Go

MileagePlus Sign In

MileagePlus number: PIN/Password: Go

Remember Me Forgot PIN? Sign In

Not a member? Join Now

Need help signing in? Visit the United Hub for information about PINs and passwords.

United MileagePlus Explorer Business Card Earn 30,000 Bonus Miles Learn More

Your social network, united. Join our vibrant online community and be a part of the conversation. Learn more >

GE Capital Retail Bank optimizer+plus 1-888-455-5241

HIGH YIELD SAVINGS ACCOUNT 0.95% APY* On all balances

Open an account today.

*Trademark of GE Capital Retail Bank. † See disclosures. Member FDIC.

Get an exclusive look at the new United T2 at LHR. Bid now MileagePlus UNITED

Display Advertisement Types

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Brand Ads

- Goal: reach & repetition
 - ▣ For awareness and image
- Common Characteristics
 - ▣ Targeted to a large group
 - ▣ Large number of Impressions
 - ▣ Guaranteed delivery
- Sample Advertisers
 - ▣ Ford (weekend auto sale)
 - ▣ Disney (movie openings)
 - ▣ Shopping Center (location)

Performance Ads

- Goal: measurable action now
 - ▣ Click, fill form, or buy.
- Common Characteristics
 - ▣ Targeted to an individual
 - ▣ Smaller number of impressions
 - ▣ Sell individual impressions
- Sample Advertisers
 - ▣ Amazon (re-targeting)
 - ▣ Hertz (car rental)
 - ▣ Quicken mortgage (refinance)

Danger of Adverse Selection

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Brand Advertisers

- Mostly buy large numbers of impressions.
- Receive deferred, aggregated data about performance of the whole ad campaign
- Cannot easily distinguish low-performing ads and publishers

Performance Advertisers

- Mostly select individual impressions using private cookies.
- Receive immediate, detailed data about the performance of individual ads
- Can quickly identify low-performing ads and publishers

If brand and performance advertisers' values are "positively correlated," then brand advertisers may suffer adverse selection.

6 Matching with Adverse Selection

Modeling the problem

Model

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- There are $N + 1$ advertisers, with $N \geq 2$
- The value of an impression to advertiser i is $X_i = C M_i$
- C is the (random) **common value factor** and
 - ▣ M_i is the (random) **match value factor** for bidder i
- **Key Assumptions**
 1. Advertiser 0 (the “brand advertiser”) does not observe X_0
 2. Performance advertisers $n = 1, \dots, N$ observe their values X_n
Define $X = (X_1, \dots, X_n)$.
 3. The common value factor C is statistically independent of the random vector $M \stackrel{\text{def}}{=} (M_0, \dots, M_N)$

A Market Design Approach

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- Compare the “restricted-worst-case efficiency” (and later, revenues) of alternative mechanisms.
- The mechanisms considered are:
 1. “Bayes optimal” mechanism
 2. Our benchmark: “Omniscient” mechanism with C observed
 3. Second-price auction
 4. Our new “Modified second-bid auction”
in which the highest performance bidder wins *if the ratio of the highest to second-highest performance bid exceeds a threshold.*

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Bayesian Optimal Mechanism

OPT ...and its drawbacks

Optimal Mechanism Formulation

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- $z_i(X)$ is probability that i wins, given X
- $p_i(X)$ is i 's expected payment, given X

- Efficiency Objective
 - ▣ Goal is to maximize $E[\sum_{i=0}^n X_i z_i(X)]$
 - subject to dominant-strategy incentive constraints and participation constraints
 - ▣ Let OPT be the mechanism that does that.

Example

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- Assume that M_1, \dots, M_n are IID and that...

$$P\{C = 1\} = P\{C = 2\} = \frac{1}{2}$$

$$\text{For } j = 1, 2, 3, P\{M_j = 1\} = P\{M_j = 2\} = P\{M_j = 4\} = \frac{1}{3}$$

$$3 < E[M_0] < 4$$

- So, it is efficient to assign this impression to a performance advertiser $j \neq 0$ only if and only if $M_j = 4$.

OPT in the Example

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- The expected-efficiency-maximizing assignment with $N = 2$ is:
 - ▣ There are two easy conditions to analyze:
 - If $X_{(1)} \in \{1, 2\}$, then $M_{(1)} \leq 2 < E[M_0] \Rightarrow$ brand advertiser wins
 - If $X_{(1)} = 8$, then $M_{(1)} = 4 > E[M_0] \Rightarrow$ top performance advertiser wins
 - ▣ If $X_{(1)} = 4$, assignment hinges on $X_{(2)}$ and particularly whether $E[M_{(1)} | X_{(1)}, X_{(2)}] \geq E[M_0]$.
 - If $X_{(2)} = 1$, then $M_{(1)} = 4 \Rightarrow$ top performance advertiser wins
 - If $X_{(2)} = 2$ or 4 , then $E[M_{(1)} | X_{(1)}, X_{(2)}] = 3 < E[M_0] \Rightarrow$ brand advertiser wins
 - If $X_{(2)} = 2$, then $\Pr\{C = 1, M_{(1)} = 4, M_{(2)} = 2 | X_{(1)}, X_{(2)}\} = \Pr\{C = 2, M_{(1)} = 2, M_{(2)} = 1 | X_{(1)}, X_{(2)}\} = \frac{1}{2}$.
 - If $X_{(2)} = 4$, then $\Pr\{C = 1, M_{(1)} = M_{(2)} = 4 | X_{(1)}, X_{(2)}\} = \Pr\{C = 2, M_{(1)} = M_{(2)} = 2 | X_{(1)}, X_{(2)}\} = \frac{1}{2}$.

Three Concerns about OPT

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- The example highlights some troublesome attributes of OPT
 1. *Sensitivity*: OPT is sensitive to detailed distributional assumptions.
 2. *False-name bidding*: Performance advertiser n with value $X_n = 4$ can benefit by submitting a *additional*, false-name bid of $X_{\hat{n}} = 1$ (because that encourages the auctioneer to infer that $M_n = 4$ whenever X_n is the maximum performance value.)
 3. *Adverse selection*: The brand advertiser wins $4/9$ of high-value impressions, but $7/9$ of low-value ones.
 - This possibility can be problematic, especially if the brand advertiser is uninformed about the other bidders and the model parameters, and so is challenged even to estimate these fractions.

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The Omniscient Benchmark

OMN, in which the auctioneer observes both the bids and C

OMN Benchmark

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- Extreme assumption: the auctioneer can gather *perfect information* about the common factor C and can allocate without facing incentive constraints.

- Auctioneer could then achieve this value:

$$V(OMN) = E[\max(X_0, X_1, \dots, X_n)],$$

$$\text{where } X_0 = CE[M_0]$$

- Performance of last two mechanisms is measured relative to $V(OMN)$.

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MSB Characterization

Modified Second Bid auction characterized by its properties

Some Mechanism Properties

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- A mechanism is
 - ▣ *anonymous* (among performance advertisers) if...
 - ▣ *strategy-proof* if...
 - ▣ *fully strategy-proof* if, in addition, it is both
 - *bidder false-name proof*: no bidder can benefit by submitting multiple bids, and
 - *publisher false-name proof*: the seller cannot benefit by submitting “low” bids (below all performance bids)
 - ▣ *adverse-selection free* if for every joint distribution on (C, M) such that C and M are independent, $z_0(X)$ is statistically independent of C .

Characterization Theorem

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- **Definition.** A direct mechanism is a *modified second bid auction* if for some $\alpha \geq 1$,
 - ▣ If $\frac{X_{(1)}}{X_{(2)}} > \alpha$, then the highest performance advertiser wins & pays $\alpha X_{(2)}$.
 - ▣ If $\frac{X_{(1)}}{X_{(2)}} \leq \alpha$, then the brand advertiser wins (and pays its contract price).

- **Theorem.** A deterministic mechanism (z, p) is anonymous, fully strategy-proof, and adverse selection free *if and only if* it is a modified second bid auction.

Proof Ideas

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1. Deterministic & strategy-proof mechanism \Leftrightarrow threshold auction.
2. ...+Anonymous \Leftrightarrow the same threshold function for all performance bidders.
3. ...+False-name proof \Leftrightarrow the threshold depends only on the second highest bid.
4. ...+Adverse-selection free \Leftrightarrow the allocation depends on ratio of two highest bids.

Comparing MSB_{α} and SP_r to OMN

MSB_{α} : modified second-bid auction

SP_r : second-price auction with reserve

Assumptions for Comparison

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- Evaluate MSB_α and SP_r mechanisms in worst case over a limited family of environments, in which...
 - ▣ M_1, \dots, M_N are IID from a distribution F .
 - ▣ C is drawn from distribution G .
 - ▣ $N \geq 2$ and $E[M_0] \geq 0$ are free to vary.

Efficiency Performance

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□ **Theorem.** (Comparing SP_r and MSB_α to OMN)

1. Assuming Nash equilibrium bidding by the brand advertiser, both MSB and SP have similar worst case performance:

$$\inf_{F,G,N \geq 2, E[M_0] \geq 0} \max_{\alpha} \frac{V(MSB_\alpha)}{V(OMN)} = \frac{1}{2}$$

$$\inf_{F,G,N \geq 2, E[M_0] \geq 0} \max_r \frac{V(SP_r)}{V(OMN)} = \frac{1}{2}$$

2. Further restricting F and/or G to be drawn from power law distributions \mathcal{P} ,

$$\inf_{F \in \mathcal{P}, G \in \mathcal{P}, N \geq 2, E[M_0] \geq 0} \max_r \frac{V(SP_r)}{V(OMN)} = \frac{1}{2}$$

$$\inf_{F \in \mathcal{P}, G, N \geq 2, E[M_0] \geq 0} \max_{\alpha} \frac{V(MSB_\alpha)}{V(OMN)} \approx 0.948$$

Revenue Performance

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- **Theorem.** Fix a number of bidders N and assume that the publisher shares in the rents from brand advertising in any fixed proportions, say $(\delta, 1 - \delta)$.
- If F is a power law distribution, then there is some α such that MSB_α achieves at least 94.8% of the expected revenue from the corresponding expected-revenue-maximizing strategy-proof auction $REVMAX$.

Conclusion

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- Adverse selection can be neutralized, without encouraging false-name bidding, **provided that $X_n = CM_n$ and C and M are independent.**
- The cost of doing that is low, even without observing the common value factor C , **provided that the tails of the distribution are fat (power law).**
- For real applications, we need to evaluate...
 - ▣ Is adverse selection important?
 - ▣ Are match values independent?
 - ▣ Are match-value distributions fat-tailed?

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End