Measuring the Effects of Advertising: The Digital Frontier

Randall A. Lewis, Google, Inc.
Justin M. Rao, Microsoft Research
David H. Reiley, Yahoo! Research

Introduction

- Advertising: $200B/yr., ~2% GDP since 1910
- "Free" services: Print, TV, email, social networking, web content
- Digital era: New scale & granularity of measurement
- But, flaws in standard industry practice conflate correlation & causation
- Fundamental economic "impossibilities" in adfx measurement
- Experiments provide unbiased measurement
- New technology, new questions, and new challenges.

1. Selection and Power

- Economics: Cost Effectiveness
  - Per capita advertising: $500 annually, $1.35 daily profits to break even (~$5 sales)

- Statistics: Power

$$\Delta\bar{y} \equiv \bar{y}_E - \bar{y}_U$$

$$R^2 = \frac{1}{4}\left(\frac{\Delta\bar{y}}{\hat{\sigma}}\right)^2$$

$$t_{\Delta\bar{y}} = \frac{\Delta\bar{y}}{\hat{\sigma}_{\Delta\bar{y}}} = \sqrt{\frac{N}{2}}\left(\frac{\Delta\bar{y}}{\hat{\sigma}}\right)$$

Example: a cost-effective campaign

- Campaign Cost: $0.14 per customer
  - 20-100 display ad impressions @ $1-5 CPM
- Mean Sales: $7
- Std. Dev.: $75
- Margin: 50%
- Incremental Sales: $0.35 ==> Profit $0.175
- ROI: 25%
  - $0.175 / $0.14 = 125%

$$R^2 = \frac{1}{4} \cdot \left(\frac{\$0.35}{\$75} \right)^2 = 0.0000054$$

Small effects, large biases

- Small expected R^2 leaves room for bias.
  - Omitted variables correlated with ad exposure that significantly explain sales.

- Small expected R^2 requires large sample.
  - Even with randomization, detecting economically valuable effects can be really hard!

- Observational methods are poorly suited to deal with small effect, large endogeneity.

2 The click and related metrics

- CTR lets us easily measure something
  - Convenient
  - Endogenous
- Clicks aren't what advertisers seek
  - Conversions occur with and without clicks
  - Conversions occur both online and offline
  - Brand advertisers seek awareness
- "Cost per acquisition" campaigns
  - Links some user-level action to the ad
- Attribution models proliferate
  - "first-click," "last-click," etc.
  - Ad-hoc assumptions to divvy up credit
- Experiments provide a better way

3 A case study of a large-scale advertising experiment

- Lewis & Reiley, "Does Retail Advertising Work?"
  - Link ad exposure to a retailer's sales data.
  - Estimate a profitable, albeit noisy impact of ads.
- Johnson, Lewis, & Reiley follow up paper.
  - Use a much higher-powered experimental design
  - Corroborate the findings in Lewis & Reiley

4 Activity bias

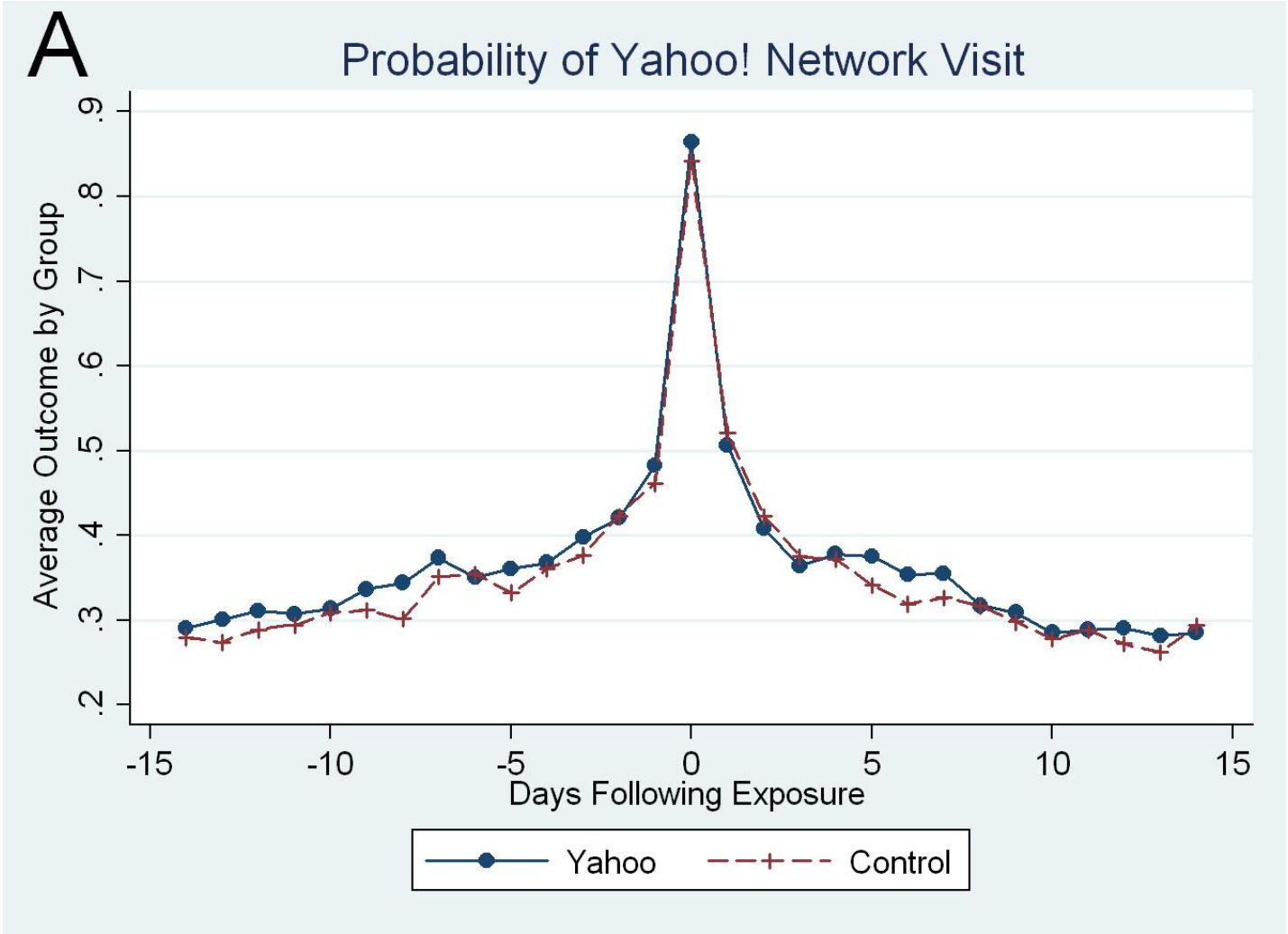
"Activity bias" is a form of selection bias:

1. When you're online, you see ads.
2. When you're online, you do lots of other things, too.

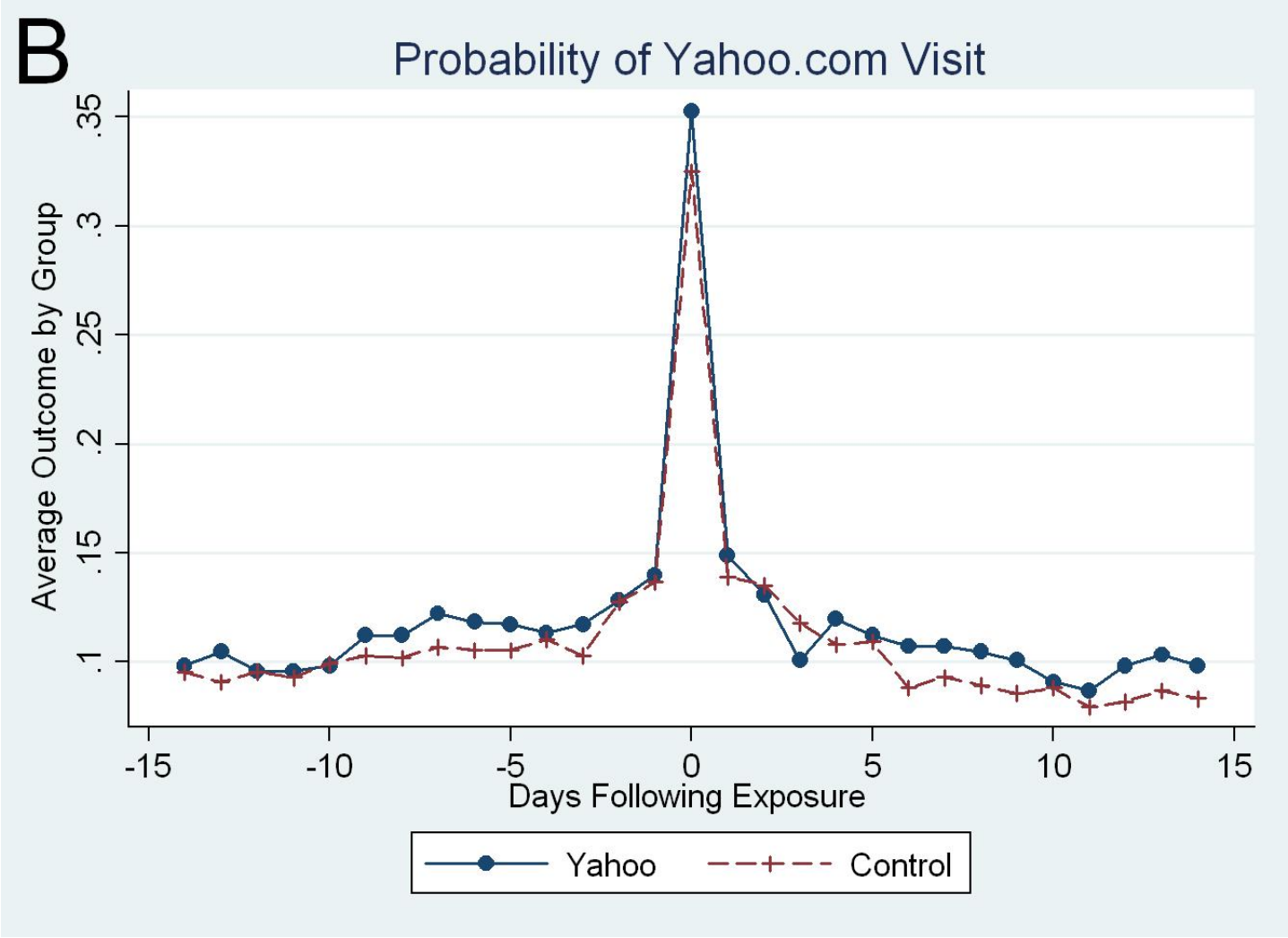
- Exposed users in a campaign tends to be more active online and eligible for the ads.
- Unexposed users either 1) were not online or 2) failed to qualify for the campaign.

Lewis, Rao, & Reiley (2011)

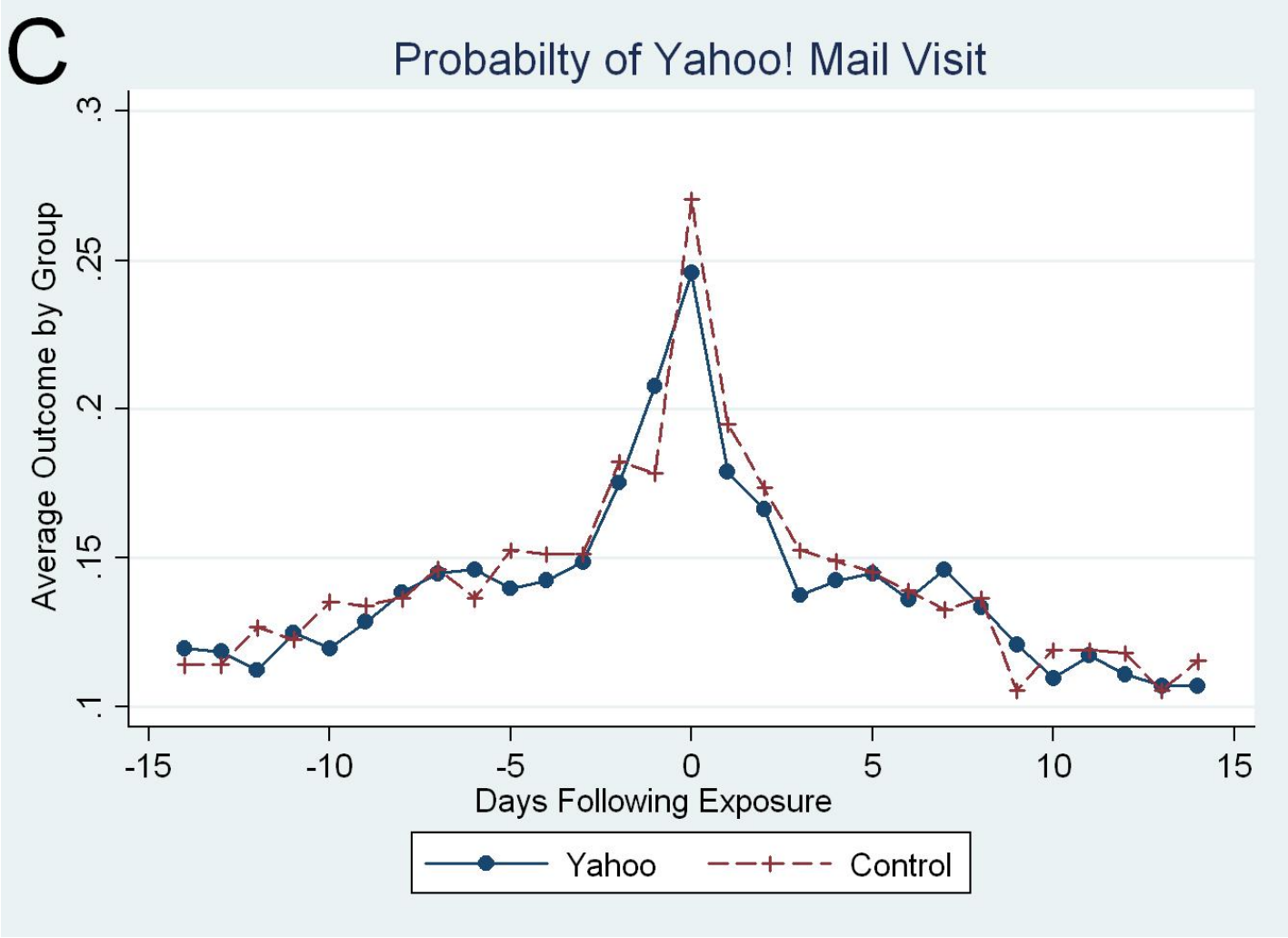
Example of Activity Bias



Example of Activity Bias



Example of Activity Bias



5 Long run effects

- Intuition: Signal declines relative to noise
  - Ads have a finite return on a fixed short-term investment
  - Most of the effect is in the short-run (not all ads can have huge long-run effects)
  - But variance grows with time

$$t_{\Delta\bar{y}_T} = \sqrt{\frac{N}{2}}\left(\frac{\sum_{t=1}^{T}\Delta\bar{y}_t}{\sqrt{T}\hat{\sigma}}\right)$$

$$t_{\Delta\bar{y}_T} < t_{\Delta\bar{y}_{T+1}} \Rightarrow \frac{1}{2}\cdot\frac{1}{T}\sum_{t=1}^{T}\Delta\bar{y}_t < \Delta\bar{y}_{T+1}$$

6 Moving forward: Overcoming Challenges

- Better experimentation infrastructure
  - "Ghost Ads" or resold placebo impressions
  - Larger control groups
  - Concentrated exposure (larger average impact)
  - Informed priors, updating expected effectiveness
  - More relevant variables to predict baseline behaviors (past sales, etc.)
- New media technologies
  - Digital TV (Xbox, Google TV, etc.)
  - Easier linking of exposure with outcomes and behaviors
- New questions
  - New digital advertising with better measureability

7 Conclusion

- Science of adfx has evolved considerably
- Econometrics of adfx expects economically large, but statistically small effects
- Experiments to measure unbiasedly, lay bare biases in commonly applied techniques
  - "Activity bias"
  - Omitted variables bias & other small, but economically relevant endogeneity biases
- Many new opportunities--but proceed with caution!