Impact of Advertising on Sales

Marketing Analytics

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

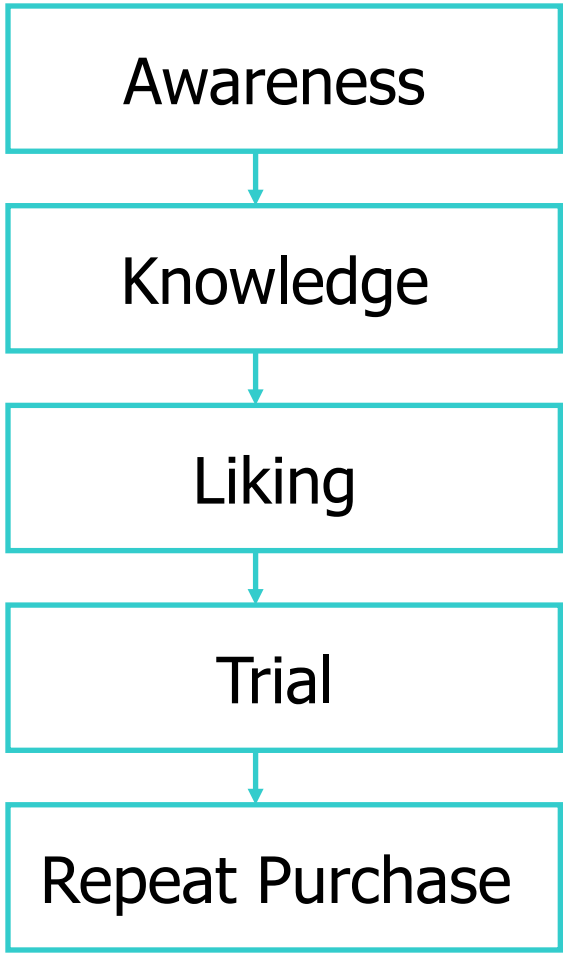
John Wanamaker

Father of modern advertising, 1838-1922

Communications Mix

- Offline
  - Advertising
  - Sales Promotions
  - Personal Selling
  - Direct Marketing
  - Publicity/Public Relations
- Online
  - Web Advertising
    - Paid search
    - Display advertising
  - Owned media
    - Websites
    - Social media
  - Earned media
    - Stealth Marketing/Buzz
    - User-generated content (reviews, blogs, forums)

The Role of Advertising



Goal: Measuring the Impact of Advertising on Sales

- Two mini-cases:
  - Fruitazia (offline advertising)
  - Bazaar.com (paid search advertising)

Mini-Case: Fruitazia*

- Contemplates the launch of a new organic, fruit juice
- Company is unsure about:
  - What price to charge
  - How much to spend on advertising
- Run a test market experiment in a representative set of US cities for 6 months

*Case data are simulated

Test Market Design

		Price per Liter		
		L $3.90	**M** $4.90	**H** $5.90
Advertising	**L** $1,000,000 Three cities	**5** *supermarkets*	**5** *supermarkets*	**5** *supermarkets*
	H $2,000,000 Three cities	**5** *supermarkets*	**5** *supermarkets*	**5** *supermarkets*

Test Market Data

Sales	Price	AdSpend
499	3.9	1
595	3.9	1
496	3.9	1
607	3.9	1
550	3.9	1
989	3.9	2
721	3.9	2
823	3.9	2
1001	3.9	2
881	3.9	2
382	4.9	1
429	4.9	1
410	4.9	1
500	4.9	1
430	4.9	1
522	4.9	2
800	4.9	2
612	4.9	2
633	4.9	2
646	4.9	2
374	5.9	1
437	5.9	1
385	5.9	1
313	5.9	1
378	5.9	1
332	5.9	2
479	5.9	2
468	5.9	2
467	5.9	2
438	5.9	2

```r
# loading data
data <- read.csv(file = "fruitazia.csv")
```

Sales are in thousands of cases.
Price is in Dollars.
Ad spend is in Million Dollars.

What can you say about the effect of advertising on sales?

Average sales by price and advertising levels

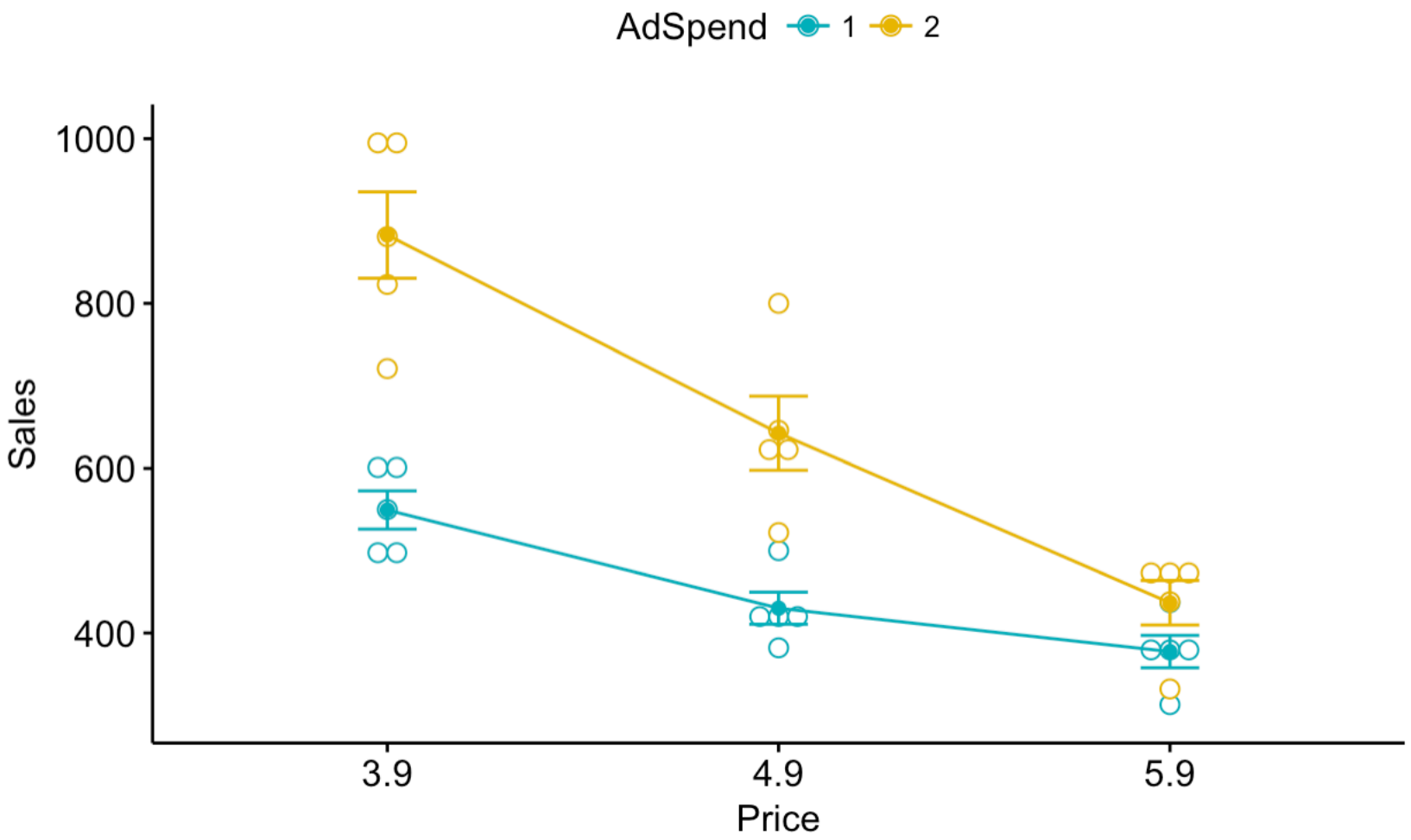
	Price			
Advertising	$3.90	$4.90	$5.90	Mean Sales
$1 Million	549	430	377	452
$2 Million	883	643	437	654
Mean Sales	716	536	407	369

Table based on:

```
kable(aggregate(Sales ~ Price + AdSpend, data=data, FUN=mean))
```

Plotting the Data

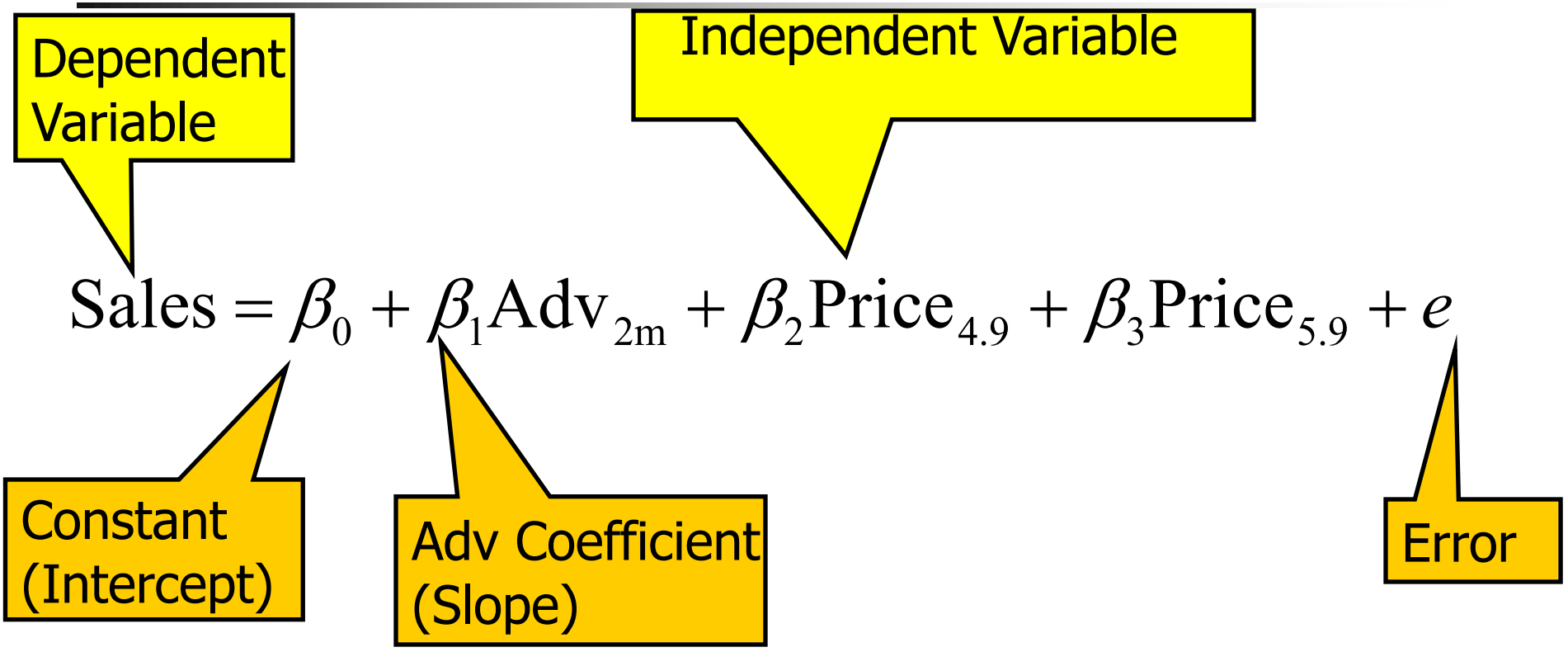
```
library("ggpubr")
ggline(data, x = "Price", y = "Sales", color = "AdSpend",
       add = c("mean_se", "dotplot"), palette = c("#00AFBB", "#E7B800"))
```



Analyzing Data Using Regression

Sales	Price	AdSpend	AdSpend2	Price4.9	Price5.9
499	3.9	1	0	0	0
595	3.9	1	0	0	0
496	3.9	1	0	0	0
607	3.9	1	0	0	0
550	3.9	1	0	0	0
989	3.9	2	1	0	0
721	3.9	2	1	0	0
823	3.9	2	1	0	0
1001	3.9	2	1	0	0
881	3.9	2	1	0	0
382	4.9	1	0	1	0
429	4.9	1	0	1	0
410	4.9	1	0	1	0
500	4.9	1	0	1	0
430	4.9	1	0	1	0
522	4.9	2	1	1	0
800	4.9	2	1	1	0
612	4.9	2	1	1	0
633	4.9	2	1	1	0
646	4.9	2	1	1	0
374	5.9	1	0	0	1
437	5.9	1	0	0	1
385	5.9	1	0	0	1
313	5.9	1	0	0	1
378	5.9	1	0	0	1
332	5.9	2	1	0	1
479	5.9	2	1	0	1
468	5.9	2	1	0	1
467	5.9	2	1	0	1
438	5.9	2	1	0	1

Regression Model



```
model <- lm(Sales ~ Price + AdSpend, data=data)
summary(model)
```

Let's look at the output

```
Call:
lm(formula = Sales ~ Price + AdSpend, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-176.00  -50.38   -7.40   64.35  183.90

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   615.30      34.39  17.893 3.89e-16 ***
Price4.9     -179.80      42.12  -4.269 0.000231 ***
Price5.9     -309.10      42.12  -7.339 8.56e-08 ***
AdSpend2      201.80      34.39   5.868 3.46e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 94.17 on 26 degrees of freedom
Multiple R-squared:  0.7735,  Adjusted R-squared:  0.7474
F-statistic: 29.59 on 3 and 26 DF,  p-value: 1.537e-08
```

All regression coefficients are significant since all p-values are less than 0.05

R-squared: 77.35% of variability of sales is explained by price and advertising variabilities

P-value: The chance of observing an F value as high as 29.59 if H_0: $\beta_1=\beta_2=\beta_3=0$ is true is .000

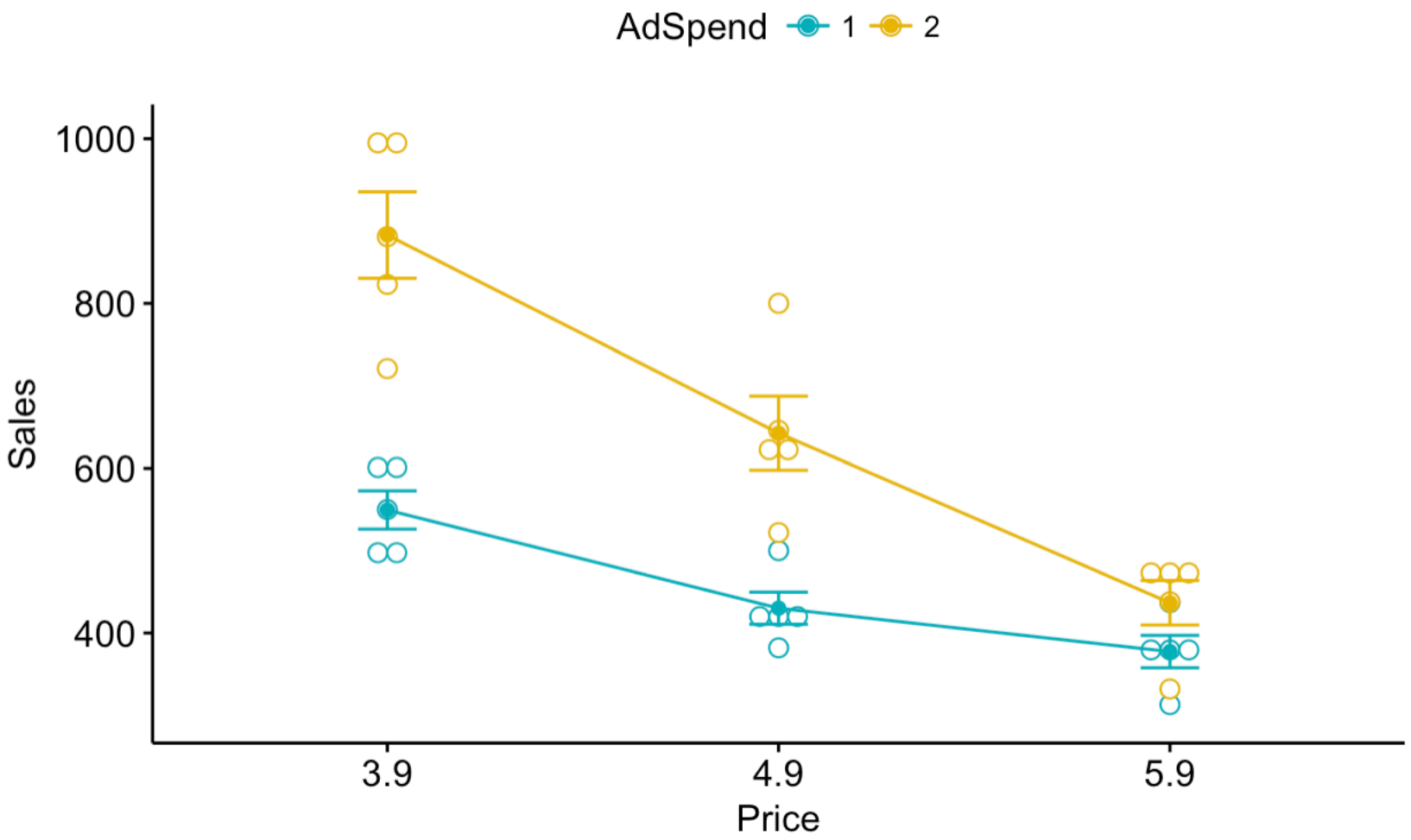
Interpreting the Estimated Regression Equation

$$\text{Sales} = 615.3 + 201.8\text{Adv}_{2m} - 179.8\text{Price}_{4.9} - 309.1\text{Price}_{5.9}$$

Sales increase by 201.8K cases when adv increases from $1 to $2m

Sales decrease by 309K cases when price increases from $3.9 to $5.9 per liter

The Interaction Effects between Advertising and Price



Accounting for Interaction Effects

Sales	Price	AdSpend	AdSpend2	Price4.9	Price5.9	**Price4.9:AdSpend2**	**Price5.9:AdSpend2**
499	3.9	1	0	0	0	0	0
595	3.9	1	0	0	0	0	0
496	3.9	1	0	0	0	0	0
607	3.9	1	0	0	0	0	0
550	3.9	1	0	0	0	0	0
989	3.9	2	1	0	0	0	0
721	3.9	2	1	0	0	0	0
823	3.9	2	1	0	0	0	0
1001	3.9	2	1	0	0	0	0
881	3.9	2	1	0	0	0	0
382	4.9	1	0	1	0	0	0
429	4.9	1	0	1	0	0	0
410	4.9	1	0	1	0	0	0
500	4.9	1	0	1	0	0	0
430	4.9	1	0	1	0	0	0
522	4.9	2	1	1	0	1	0
800	4.9	2	1	1	0	1	0
612	4.9	2	1	1	0	1	0
633	4.9	2	1	1	0	1	0
646	4.9	2	1	1	0	1	0
374	5.9	1	0	0	1	0	0
437	5.9	1	0	0	1	0	0
385	5.9	1	0	0	1	0	0
313	5.9	1	0	0	1	0	0
378	5.9	1	0	0	1	0	0
332	5.9	2	1	0	1	0	1
479	5.9	2	1	0	1	0	1
468	5.9	2	1	0	1	0	1
467	5.9	2	1	0	1	0	1
438	5.9	2	1	0	1	0	1

```
model1 <- lm(Sales ~ Price * AdSpend, data=data)
summary(model1)
```

Regression Results

```
Call:
lm(formula = Sales ~ Price * AdSpend, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-162.00  -43.80    0.20   39.45  157.40

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)         549.40      33.69  16.309 1.73e-14 ***
Price4.9           -119.20      47.64  -2.502 0.019565 *
Price5.9           -172.00      47.64  -3.610 0.001401 **
AdSpend2            333.60      47.64   7.002 3.06e-07 ***
Price4.9:AdSpend2  -121.20      67.37  -1.799 0.084625 .
Price5.9:AdSpend2  -274.20      67.37  -4.070 0.000442 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 75.33 on 24 degrees of freedom
Multiple R-squared:  0.8662, Adjusted R-squared:  0.8384
F-statistic: 31.08 on 5 and 24 DF,  p-value: 9.777e-10
```

Summary: Impact of Advertising on Sales

Effect of increased ad spend on sales at different price levels

$3.9	**$4.9**	**$5.9**
+333.6	+212.4	+59.4
	333.6 - 121.2	333.6 - 274.2

Key Results

- Advertising and price significantly impact sales
- Advertising works best when coupled with low price
  - Advertising and price interact
  - If the objective is to maximize sales or market share, then it is best to charge low price ($3.9 per liter) and spend more on advertising ($2m)

Mini-Case: Bazaar.com*

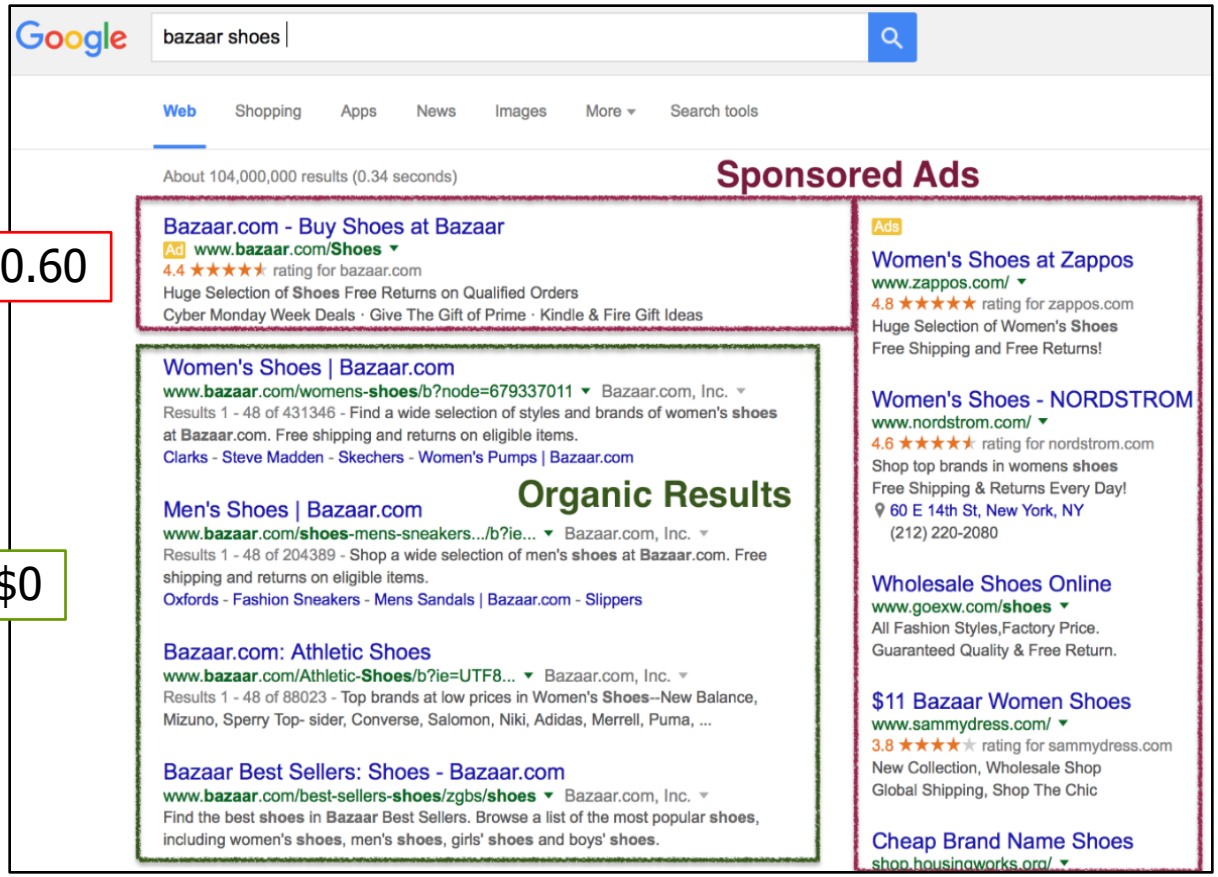
- Online retailer
- Run paid-search ads on Google and Bing
- Wants to measure ROI on paid-search ads for branded keywords (e.g., bazaar shoes)
- Company has weekly traffic data from Google and Bing

*Case based on Columbia CaseWorks ID#170508: "Measuring ROI on Sponsored Search Ads," by Kinshuk Jerath, Columbia University

Sponsored Search for Branded Keywords

Cost per click: $0.60

Cost per click: $0



Sponsored Search Statistics for Branded Keywords*

- Cost per click: $0.60
- Conversion rate (% of clicks that buy)=12%
- Average profit per conversion (buyer)=$21
- Expected average profit per click =$21*12%=$2.52
  - Expected profit is the same whether the click is from sponsored or organic search

What is the ROI of the Campaign?

Cost per click: $0.60
Conversion rate (% of clicks that buy)=12%
Average profit per conversion (buyer)=$21
Average profit per click=$21*12%=$2.52

- ROI=($2.52-$0.60)/$0.60 = 320%
  - An incremental $1 spent on paid-search generates an incremental contribution (net of cost of advertising) of $3.20
- Is this right?

Google and Bing Weekly Traffic

Table 1: Weekly traffic from Google by origin of click

Week	1	2	3	4	5	6	7	8	9	10	11	12
Sponsored	32,269	31,951	32,143	31,417	31,194	31,576	30,951	30,611	30,401	0	0	0
Organic	127,876	128,169	125,717	126,264	123,871	124,053	126,105	123,064	121,637	150,188	148,658	146,584
Total	160,145	160,120	157,860	157,681	155,065	155,629	157,056	153,675	152,038	150,188	148,658	146,584

Table 2: Weekly traffic from Bing by origin of click

Week	1	2	3	4	5	6	7	8	9	10	11	12
Sponsored	3,965	3,984	3,960	3,952	3,874	3,932	3,890	3,883	3,843	3,815	3,754	3,754
Organic	15,805	15,964	15,815	15,810	15,633	15,797	15,462	15,309	15,499	15,185	15,159	15,036
Total	19,770	19,948	19,775	19,762	19,507	19,729	19,352	19,192	19,342	19,000	18,913	18,790

Google Clicks as a Natural Experiment

Table 1: Weekly traffic from Google by origin of click

Week	1	2	3	4	5	6	7	8	9	10	11	12
Sponsored	32,269	31,951	32,143	31,417	31,194	31,576	30,951	30,611	30,401	0	0	0
Organic	127,876	128,169	125,717	126,264	123,871	124,053	126,105	123,064	121,637	150,188	148,658	146,584
Total	160,145	160,120	157,860	157,681	155,065	155,629	157,056	153,675	152,038	150,188	148,658	146,584

What is the ROI of this campaign?

Average Weekly Clicks before and after Google Campaign

Clicks	Weeks 1-9	Weeks 10-12	Difference
Sponsored	31390	0	-31390
Organic	125,195	148,477	23282
Total	156,585	148,477	-8109

% Loss of clicks due to absence of sponsored ads = -5.18%=-8109/156,585

ROI based on Google Clicks

- Average weekly traffic gain from sponsored search: 8,109 clicks
  - Incremental gain from these clicks: 8,109*$2.52=$20,434
- Average weekly clicks from sponsored search: 31,390 clicks
  - Weekly cost of sponsored search: 31390*$0.60=$18,834
- ROI=($20,434-$18.834)/18,834=8.49%
- Is this OK?

Bing Clicks

Table 2: Weekly traffic from Bing by origin of click												
Week	1	2	3	4	5	6	7	8	9	10	11	12
Sponsored	3,965	3,984	3,960	3,952	3,874	3,932	3,890	3,883	3,843	3,815	3,754	3,754
Organic	15,805	15,964	15,815	15,810	15,633	15,797	15,462	15,309	15,499	15,185	15,159	15,036
Total	19,770	19,948	19,775	19,762	19,507	19,729	19,352	19,192	19,342	19,000	18,913	18,790

Is this useful information?

Average Weekly Clicks from Bing

Clicks	Weeks 1-9	Weeks 10-12	Difference
Sponsored	3,920	3,774	146
Organic	15,677	15,127	550
Total	19,597	18,901	696

In weeks 10-12, total weekly clicks from Bing decreased by 3.55%=(19,597 -18,901)/19,597 (e.g., due to seasonality)

Decline in Total Traffic with and without Sponsored Ads

Table 3: Average weekly total traffic from Google		
Weeks 1-9	Weeks 10-12	
156,585	148,477	-5.18%

Decline w/o Sponsored Ads

Table 4: Average weekly total traffic from Bing		
Weeks 1-9	Weeks 10-12	
19,597	18,901	-3.55%

Decline with Sponsored Ads

Sponsored ads increased total weekly clicks by =1.62% =5.18-3.55

ROI of Google Campaign

Table 5: Reduction in traffic in Google and Bing			
	Weeks 1-9	Weeks 10-12	Reduction in traffic (Diff 1)
Google	156,585	148,477	-5.18%
Bing	19,597	18,901	-3.55%
		Difference	-1.62%

- Incremental weekly traffic gain from sponsored search: 1.62%*156,585=2,544 clicks
  - Incremental gain from these clicks: 2,544*$2.52=$6,411
- Average weekly clicks from sponsored search: 31,390 clicks
  - Weekly cost of sponsored search: 31390*$0.60=$18,834
- ROI=($6,411-$18.834)/18,834= -66%

Breakeven Cost per Click (CPC)

- Incremental gain per week=$6,411
- Weekly cost per week=31,390clicks*CPC
- Breakeven CPC= $6,411/31,390=$0.20
- Bazaar should bid less than $0.20 on branded keywords for the campaign to be profitable

Conclusion

- Important to measure impact of advertising on sales for better resource allocation
  - Use historical data and market experiments
- Marketing activities do not act independently
  - They interact
- Regression and difference-in-difference are useful methods to quantify the impact of advertising on sales