Leeds University Business School

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Managing Resource Trade-Offs

Dr. Ashutosh Singh

Learning Objectives

- Marketing problem
  - Managing resource trade-offs
- Analysis tools
  - Market experiment
  - Marketing response model

Framework for Managing Resource Trade-Offs

Inputs

Positioning Statements
- Whom, what, and why

AER Strategies
- What strategies work best for each persona

BOR Strategies
- Brand, offering, and relationship strategies

Managing Resource Trade-Offs

Approaches & Processes
Heuristic approach
Attribution approach

Analyses
Response model attributions
Experimental-based attributions

Plans and Budgets
- Budget per marketing activity
- Allocation across categories

Performance Metrics
- Marketing metrics
- Financial metrics

Attribution Approach

- Specifies an attribution model, such that the firm learns the exact dollar impact that a small resource increase will exert, also can provide answers to the following questions:
  - What is the relative dollar value impact of a marketing investment?
  - What is the profit-maximizing level of investment?

- By using an attribution model, managers thus can allocate resources to optimize their desired outcome, as well as avoid waste or reliance on arbitrary heuristics

- These attribution models come in two main categories
  - Market response model (Marketing mix model)
  - Experiment

Managing Resource Trade-Offs I

Market Response Model

Dr. Ashutosh Singh

Outline

- Part I: Marketing Effectiveness and Resource Allocation
  - Why/how to measure returns on marketing investment?
  - Allocating marketing budgets

- Part II: Marketing Mix Modelling
  - Modelling linear regression
  - Modelling synergies between marketing mix instruments
  - Modelling carryover effects
  - Evaluating the model

Why Measure Returns on Marketing Investment?

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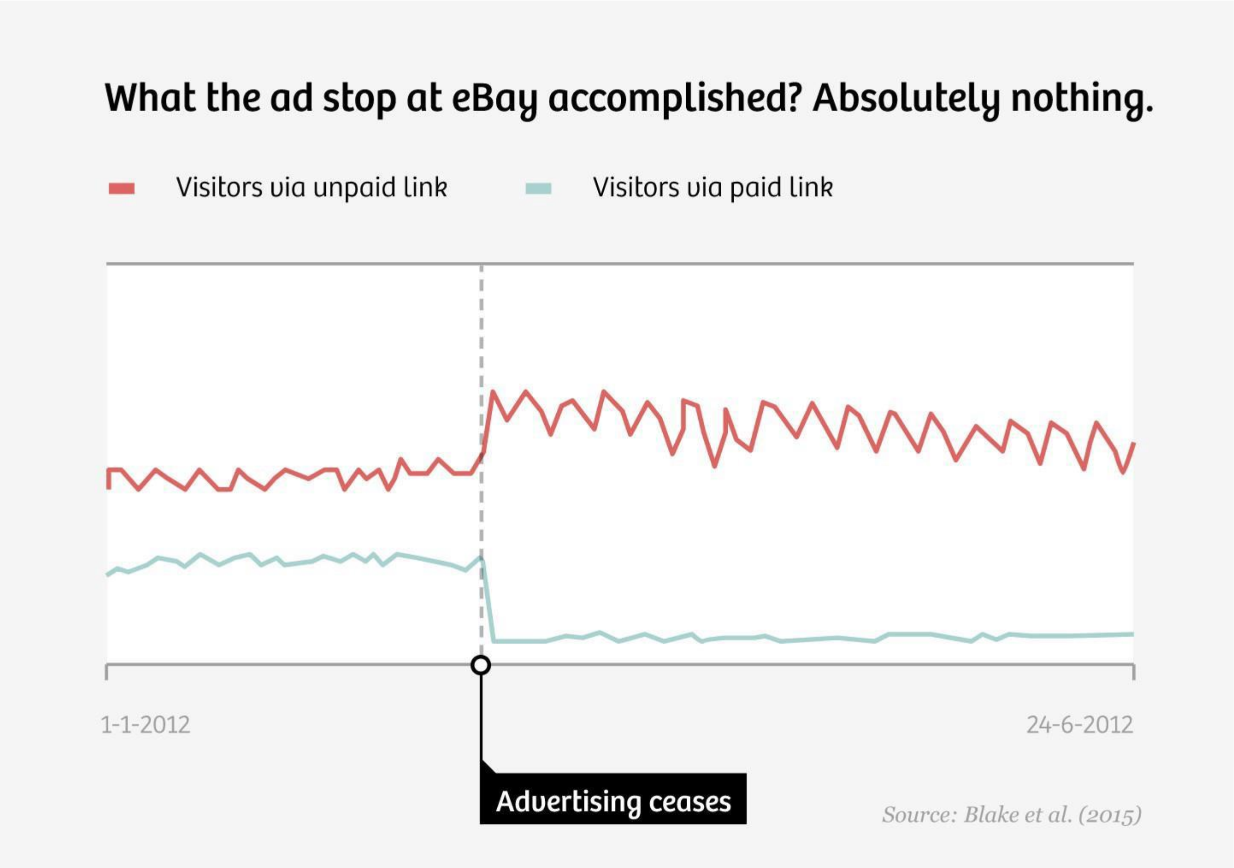
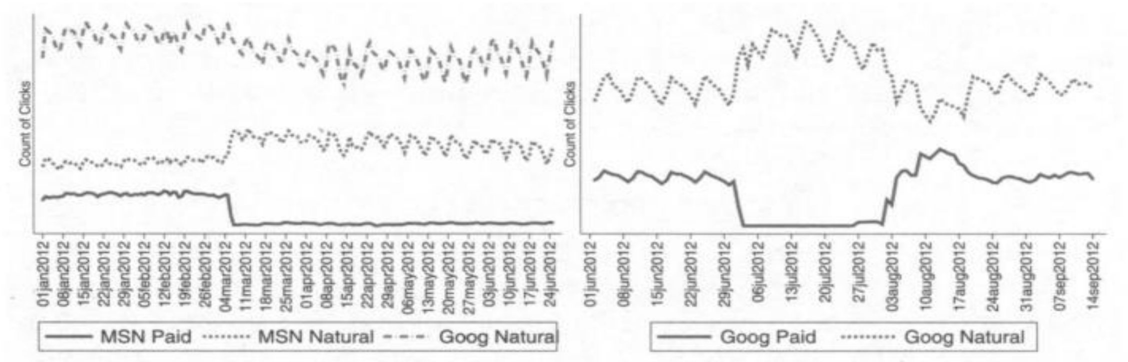


PAID SEARCH EFFECTIVENESS 161



(a) MSN Test (b) Google Test

FIGURE 2.—Brand keyword click substitution. MSN and Google click-traffic counts to eBay on searches for 'ebay' terms are shown for two experiments where paid search was suspended (panel (a)) and suspended and resumed (panel (b)).

Coca-Cola, Microsoft, Starbucks, Target, Unilever, Verizon: all the companies pulling ads from Facebook

What are market response models? How it Works?

- Using past data to uncover the relationship between marketing resources and performance, response models provide two main insights.

  -The **shape** of the relationship between marketing resources and outcomes (concave or convex).

  -Exactly how much financial outcomes would change if marketing efforts increased by 1 percent, also known as **marketing elasticity**.

How to Measure Return on Marketing Investment

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Data contains weekly sales and TV, radio, and newspaper advertising (in thousands of pounds)

	week	tv	radio	newspaper	sales
1	1	230.1	37.8	69.2	22.1
2	2	44.5	39.3	45.1	10.4
3	3	17.2	45.9	69.3	9.3
4	4	151.5	41.3	58.5	18.5
5	5	180.8	10.8	58.4	12.9
6	6	8.7	48.9	75.0	7.2
7	7	57.5	32.8	23.5	11.8
8	8	120.2	19.6	11.6	13.2
9	9	8.6	2.1	1.0	4.8
10	10	199.8	2.6	21.2	10.6

In week 1, the brand spent:

- £ 230,100 on tv ads
- £ 37,800 on radio ads
- £ 69,200 on newspaper ads

The brand sold 22,100 units

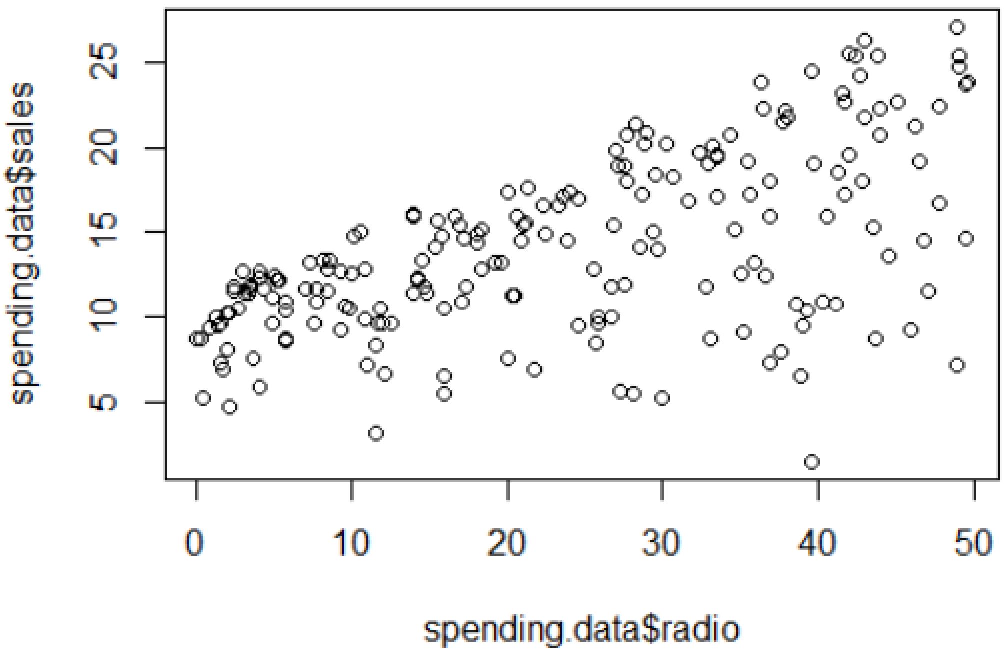
The Basics: Simple linear regression

Predictor variable → **Response variable**

Radio Advertising → Sales

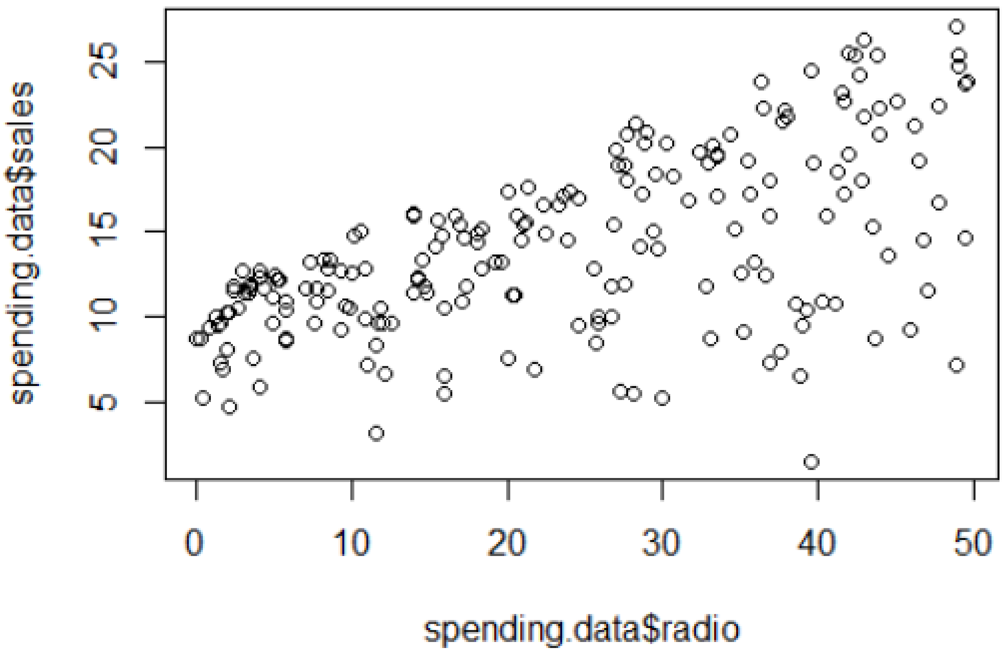
The Basics: Simple linear regression

Correlation = .58



The Basics: Simple linear regression

Sales = a+ b_1 Radio advertising



The Basics: Simple linear regression

- Does radio advertising affects sales for an electronics brand?

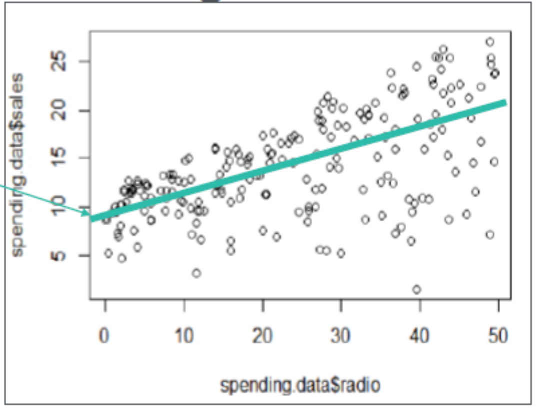
Sales = 9.31 + 0.20 Radio advertising

```
regression <- lm(sales ~ radio, data = spending.data)

summary(regression)
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  9.31164    0.56290  16.542   <2e-16 ***
radio        0.20250    0.02041   9.921   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.275 on 198 degrees of freedom
Multiple R-squared:  0.332,	Adjusted R-squared:  0.3287
F-statistic: 98.42 on 1 and 198 DF,  p-value: < 2.2e-16
```



A 1 unit (i.e. 1,000 pounds) increase in radio advertising results in ‘0.20’ (i.e. 200) additional unit sales

The Basics: Simple linear regression

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- Predict sales

Sales = 9.31 + 0.20 Radio advertising

*17.31 = 9.31 + 0.20 * 40*

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  9.31164    0.56290  16.542   <2e-16 ***
radio        0.20250    0.02041   9.921   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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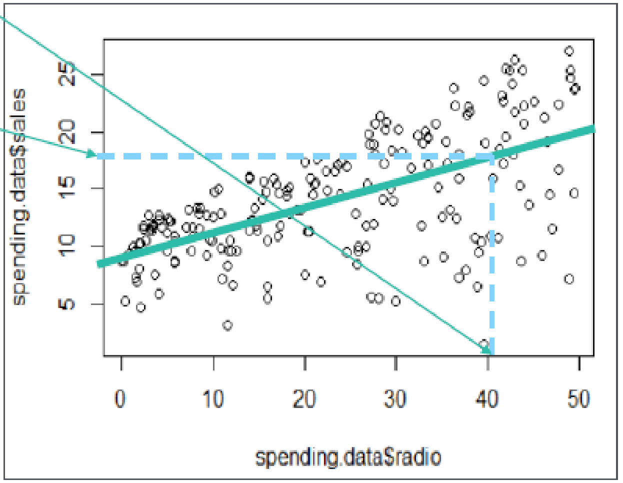
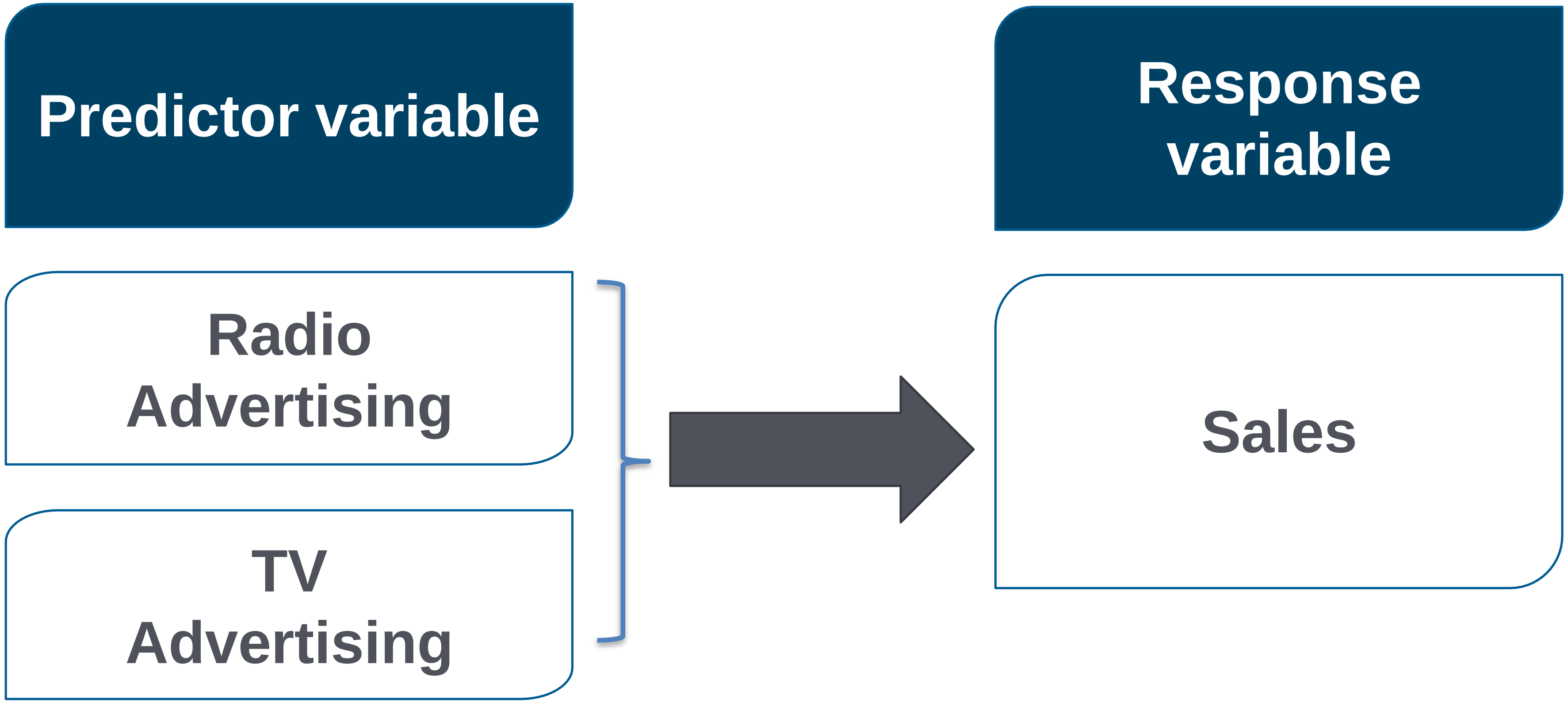


The Basics: Multiple Linear Regression



The Basics: Multiple Linear Regression

Sales =a+ b_1 Radio advertising + b_2 TV advertising

```
regression <- lm(sales ~ radio + tv, data=spending.data)
summary(regression)
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.92110    0.29449   9.919   <2e-16 ***
radio        0.18799    0.00804  23.382   <2e-16 ***
tv           0.04575    0.00139  32.909   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.681 on 197 degrees of freedom
Multiple R-squared:  0.8972,    Adjusted R-squared:  0.8962
F-statistic: 859.6 on 2 and 197 DF,  p-value: < 2.2e-16
```

The Basics: Multiple Linear Regression

Sales = 2.92 + 0.19 Radio advertising
+ 0.05 TV advertising

```
regression <- lm(sales ~ radio + tv, data=spending.data)
summary(regression)
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  2.92110    0.29449   9.919   <2e-16 ***
radio        0.18799    0.00804  23.382   <2e-16 ***
tv           0.04575    0.00139  32.909   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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```

The Basics: Multiple Linear Regression

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89.62% of the variation in sales is explained by radio and tv advertising

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  2.92110    0.29449   9.919   <2e-16 ***
radio        0.18799    0.00804  23.382   <2e-16 ***
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Multiple R-squared:  0.8972,    Adjusted R-squared:  0.8962 
F-statistic: 859.6 on 2 and 197 DF,  p-value: < 2.2e-16
```

If the p-value is lower than a treshold significance level, we can say that the result is *statistically significant*. A common rule of thumb is to set the significance level to 0.05

This is the scientific notation of 0.00000000000000022

Ratio of elasticities method

- **What is an elasticity?**
  - – % change in response variable for a 1% change in predictor variable
  - – Example: the % change in sales for a 1% change in advertising spending

Allocating Marketing Budgets

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How to obtain elasticities from a linear regression model?

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  2.938889   0.311908   9.422   <2e-16 ***
radio        0.188530   0.008611  21.893   <2e-16 ***
tv           0.045765   0.001395  32.809   <2e-16 ***
newspaper   -0.001037   0.005871  -0.177     0.86    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.686 on 196 degrees of freedom
Multiple R-squared:  0.8972,	Adjusted R-squared:  0.8956 
F-statistic: 570.3 on 3 and 196 DF,  p-value: < 2.2e-16
```

- Advertising Elasticity =
  Advertising Estimate * (**Baseline Advertising** / **Baseline Sales**)

- **Baseline Advertising** = average radio advertising spending (=23.26)
- **Baseline Sales** = average sales (=14.02)

- What is the elasticity for radio advertising?
  0.19 * (23.26/14.02) = **0.32**

➔ **A 1% increase in radio advertising results in a 0.32% increase in sales**

Modelling log-log Returns on Investment

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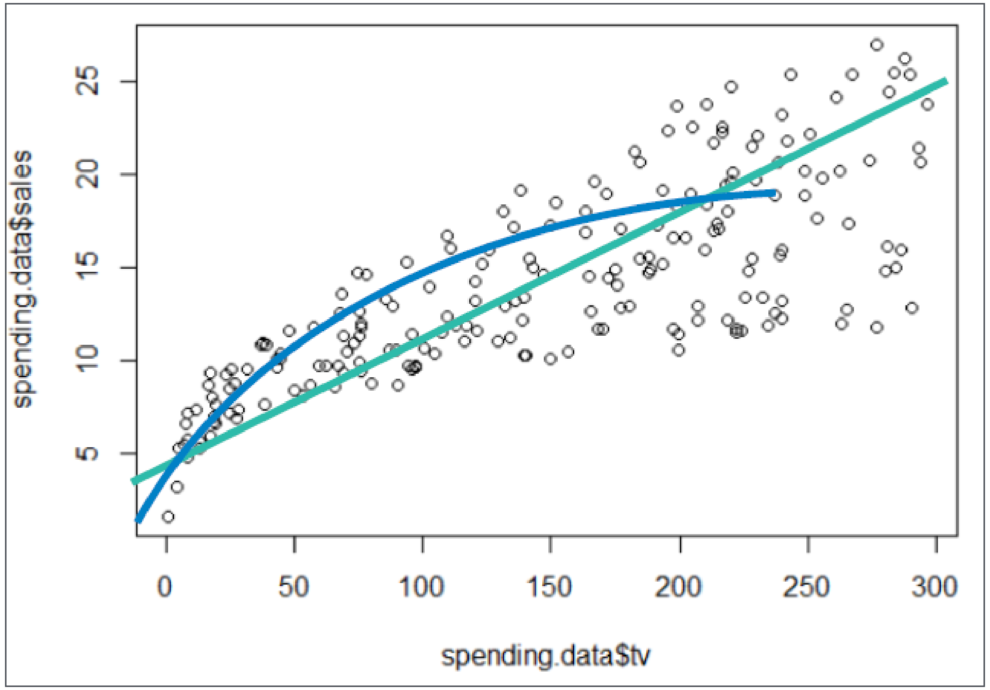
Is the relation between TV and advertising linear?



Linear Model

Log-log Model

Modelling Log-log Returns on Investment

log(Sales) = α + β1 log(Radio advertising+0.01) + β2 log(TV advertising) + β3 log(Newspaper advertising)

```r
regression <- lm(log(sales) ~ log(radio+0.01) + log(tv) + log(newspaper), data=spending.data)

summary(regression)
```

```
summary(spending.data$sales)
 Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 1.60   10.38   12.90   14.02   17.40   27.00
summary(spending.data$radio)
 Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.000   9.975  22.900  23.264  36.525  49.600
summary(spending.data$tv)
 Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.70   74.38  149.75  147.04  218.82  296.40
summary(spending.data$newspaper)
 Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.30   12.75   25.75   30.55   45.10  114.00
```

Modelling Log-log Returns on Investment


```
regression <- lm(log(sales) ~ log(radio+0.01) + log(tv) + log(newspaper), data=spending.data)

summary(regression)
```

```
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)    
(Intercept)       0.479773   0.052031   9.221   <2e-16 ***
log(radio + 0.01) 0.144177   0.007865  18.333   <2e-16 ***
log(tv)           0.349297   0.008857  39.437   <2e-16 ***
log(newspaper)    0.017488   0.009306   1.879   0.0617 .  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1254 on 196 degrees of freedom
Multiple R-squared:  0.9098,	Adjusted R-squared:  0.9084 
F-statistic: 658.7 on 3 and 196 DF,  p-value: < 2.2e-16
```

How to interpret coefficients?

➔ A 1% increase in radio advertising results in a 0.14% increase in sales

➔ A 1% increase in tv advertising results in a 0.35% increase in sales

Coefficients are elasticities!

Modelling Media Synergy

- The combined use marketing mix instruments can create **synergy effects.**
- **Synergy effects** arise when the joint impact of multiple media exceeds the total of their individual parts

Is TV advertising more effective in the presence of radio advertising?

$$
\begin{aligned}
\log(Sales) = \alpha &+ \beta 1 \log(\text{Radio advertising}+0.01) \\
&+ \beta 2 \log(\text{TV advertising}) \\
&+ \beta 3 \log(\text{Newspaper advertising}) \\
&+ \boxed{\beta 4 \log(\text{Radio advertising}+0.01) \times \log(\text{TV advertising})}
\end{aligned}
$$

Modelling carryover effects

- So far, we assumed that advertising in a given time period will only affect sales in that same time period
- In reality, the **consumer's response to advertising can be delayed**
- Not accounting for carry-over effects can cause advertising elasticities to be under-valued

Modelling carryover effects

- **Advertising adstock** measures the effect of advertising beyond the current time period
- $Adstock_t = Advertising_t + \lambda Adstock_{t-1}$
- In each time period, you are assumed to retain a fraction (λ) of your previous advertising stock
- For example, if λ equals 0.3, then adstock from one time period ago still has a 30% effect in the current time period

Modelling carryover effects

- **How to calculate Adstock levels?**
- $\text{Adstock}_t = \text{Advertising}_t + \lambda \text{Adstock}_{t-1}$

Week	Advertising	Adstock
1	450	450
2	100	235[a]
3	0	71[b]
4	200	221
5	800	866
6	400	660
7	300	498

$\lambda = 0.30$

[a] 100 + 0.3*450 = 235

[b] 0 + 0.3*235 = 71

Modelling carryover effects

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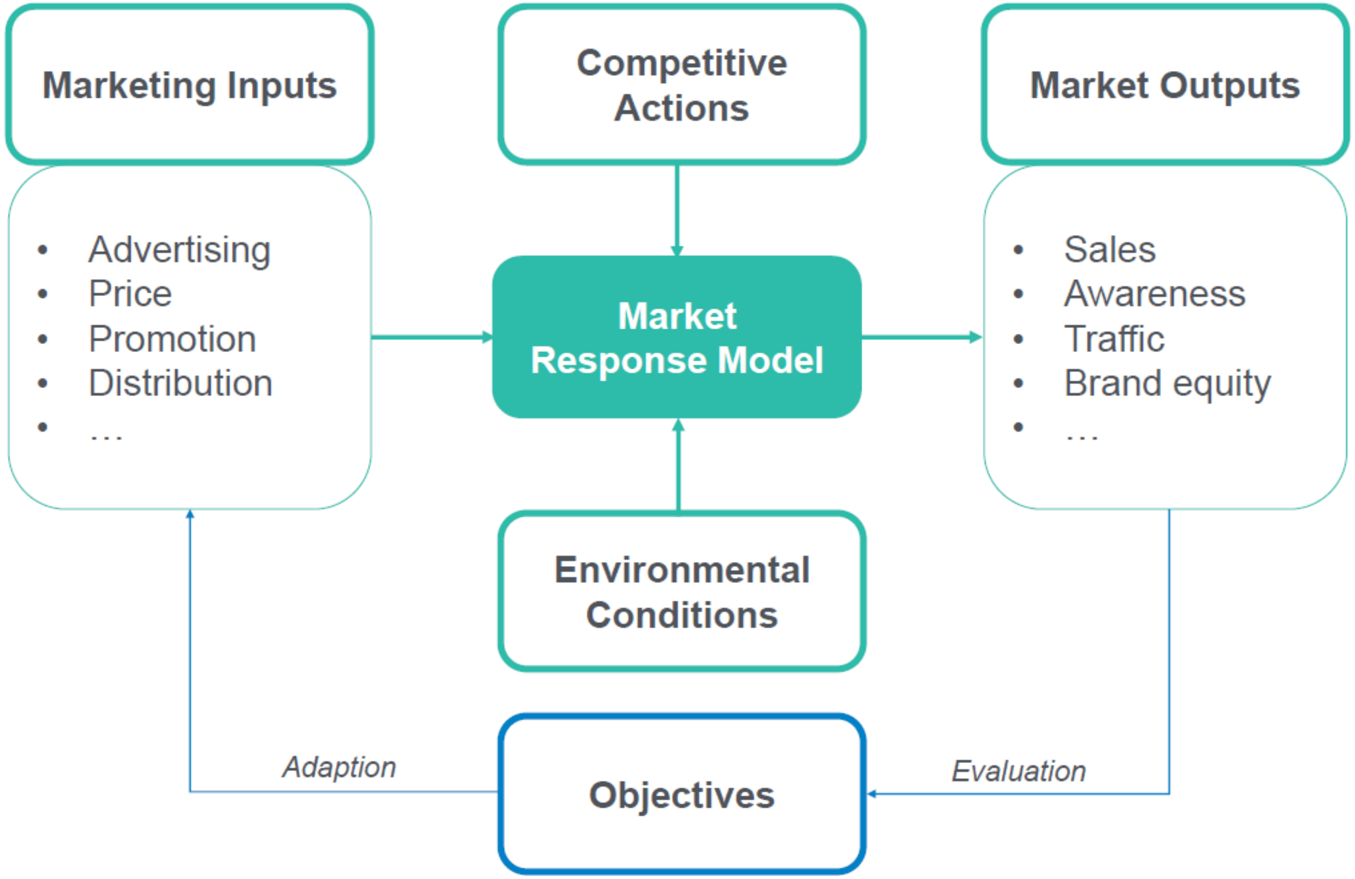
How to do this in R?

```
adstock <- function(x, rate=0.1){return(as.numeric(stats::filter(x=x, filter=rate, method="recursive")))}

spending.data <- spending.data %>%
  mutate(tv_adstock = adstock(tv),
         newspaper_adstock = adstock(newspaper),
         radio_adstock = adstock(radio))

regression <- lm(log(sales) ~ log(radio+0.01) + log(tv_adstock) + log(newspaper), data=spending.data)

summary(regression)
```

- “rate=0.1” sets λ to 0.1 (i.e. 10%)
- You can empirically test multiple values of λ

Building and Evaluating Market Response Model



Takeaways

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- All resources are limited. Managers must manage resource trade-offs to develop an effective marketing strategy.
- Approaches to managing resource trade-offs have evolved from an exclusively heuristic-based era to a data-based era, in which managers rely on statistical models and detailed information.
- A response model-based attribution approach captures the relationship between past marketing resources and past outcomes. The use of past data then can uncover the relationship between marketing resources and performance.

The Basics: Acting on output

To attract more visitors for the movie theatre you work for, you decide to lower the price of a ticket and to distribute flyers for 5 weeks in a row, for the first time.

Now your manager wants you to assess the effectiveness of these price discounts and flyers. The data analyst at your firm presents you with the following table.

How would you respond?

	Coefficient	p-value
Flyers (b_1)	-.0200	.02
Price (b_2)	.0275	.70
R^2 = .33		