Project 5: AB Testing

0. Import Data

Import Data

```
# Load control, treatment, transactions df's
control <- read.csv('data/clean/control.csv')
treatment <- read.csv('data/clean/treatment.csv')
transactions <- read.csv('data/clean/transactions.csv')
```

Check/Wrangle Data

```
# Change transactions$invoice_date to datetime
# Load dependencies
library(lubridate)
```

```
##
## Attaching package: 'lubridate'
```

```
## The following object is masked from 'package:base':
##
##     date
```

```
# Change to datetime
transactions$invoice_date <- ymd(as.character(transactions$invoice_date))
# Check
str(transactions)
```

```
## 'data.frame':    4332333 obs. of  6 variables:
##  $ store_id    : int  10018 10018 10018 10018 10018 10018 10018 10018 10018 10018 ...
##  $ invoice_date: Date, format: "2015-01-21" "2015-01-21" ...
##  $ category    : Factor w/ 6 levels "Coffee","Espresso",..: 2 4 2 2 2 2 4 2 2 4 ...
##  $ product     : Factor w/ 12 levels "Cabernet Sauvignon",..: 11 4 8 8 8 10 4 8 11 4 ...
##  $ gross_margin: num  6.74 1.1 4.18 5.98 4.79 ...
##  $ sales       : num  14.97 2.75 8.37 11.96 9.57 ...
```

```
# Remove treatment units from control units
control <- subset(control, !(store_id %in% treatment$store_id))
```

1. Choose Target Variable

The goal is to increase gross margin per week, so the performance metric is weekly_gross_margin.

2. Choose Experimental Design

The data received includes descriptive data on both stores and transactions, so a matched pair design was used.

3. Choose Experimental and Control Variables

Experimental Variable

The combination of updated restaurant menu and television advertising is the experimental variable because it was adjusted to determine its effect on the target variable, weekly gross margin.

Control Variables

List potential control variables we have data for

1. sq_ft
2. average monthly sales

Wrangle data to obtain gross margins per store

```
# Determine gross_margin

# Load dependencies
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
## The following objects are masked from 'package:lubridate':
##
##     intersect, setdiff, union
## The following objects are masked from 'package:stats':
##
##     filter, lag
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
# gross margin per store
sum_transactions <- transactions %>%
  group_by(store_id) %>%
  summarise(sum_gross_margin=sum(gross_margin))

# Join treatment/control df's to sum_gross_margin
treatment <- left_join(treatment, sum_transactions, by='store_id')
control <- left_join(control, sum_transactions, by='store_id')
```

Check correlations between sum_gross_margin and potential control variables

```
# Check correlations
cor(control[c('sum_gross_margin', 'sq_ft', 'avg_month_sales')])
```

```
##                  sum_gross_margin       sq_ft avg_month_sales
## sum_gross_margin       1.00000000 -0.02914714      0.99485333
## sq_ft                 -0.02914714  1.00000000     -0.04006262
```

```
## avg_month_sales        0.99485333 -0.04006262      1.00000000
```

Of the potential control variables of interest, sq_ft and avg_month_sales, only avg_month_sales is correlated to the target variable, sum_gross_margin. As a result, avg_month_sales was selected as the only control variable.

4. Choose the Treatment and Control Units

Treatment Units

The treatment units are the 10 stores in the treatment dataframe

Control Units

Per project guidance, two control units from the control dataframe should be matched to each treatment unit from the treatment dataframe.

```
# Load dependencies
library(MatchIt)

# Include treatment column in treatment/control df's
treatment$treatment <- 1
control$treatment <- 0

# Divide Central and West Regions
central_units <- subset(rbind(control, treatment), region=='Central')
west_units <- subset(rbind(control, treatment), region=='West')

# Match the samples
# Central
matches_central <- matchit(treatment ~ avg_month_sales,
        data=central_units,
        method='nearest',
        ratio=2)
# West
matches_west <- matchit(treatment ~ avg_month_sales,
        data=west_units,
        method='nearest',
        ratio=2)

# Obtain matrix of matched units
matches_central <- matches_central$match.matrix
matches_west <- matches_west$match.matrix

# Create df of treatment and control store_id's
# Central
tu_central <- central_units[rownames(matches_central),]$store_id
cu1_central <- central_units[matches_central[,1],]$store_id
cu2_central <- central_units[matches_central[,2],]$store_id
match_matrix_central <- data.frame(tu_central, cu1_central, cu2_central)
names(match_matrix_central) <- c('Treatment Store', 'Control Store 1', 'Control Store 2')
# West
```

```r
tu_west <- west_units[rownames(matches_west),]$store_id
cu1_west <- west_units[matches_west[,1],]$store_id
cu2_west <- west_units[matches_west[,2],]$store_id
match_matrix_west <- data.frame(tu_west, cu1_west, cu2_west)
names(match_matrix_west) <- c('Treatment Store', 'Control Store 1', 'Control Store 2')

# Combine match_matrix_central and match_matrix_west
match_matrix <- rbind(match_matrix_central, match_matrix_west)
# Display Treatment and Control Units
match_matrix
```

```
##    Treatment Store Control Store 1 Control Store 2
## 1             1664             8262             1964
## 2             1675             1857             7284
## 3             1696             7811             7334
## 4             1700             7484             6992
## 5             1712             8312             8162
## 6             2288             2409             3235
## 7             2293            12286            10518
## 8             2301             9639             9524
## 9             2322             8817             9438
## 10            2341            12019             2852
```

5. Clean and Prepare Data

Helper Functions

```r
# Filters transaction data by date and calculates the weekly gross margin per store
# Inputs transaction data, start date, and end date
# Outputs a df with store_id, weekly_gross_margins, and id columns
wgm_by_dates <- function(df, date1, date2) {
  # Calculate weekly gross margins by date
  wgm_by_dates <- subset(df, invoice_date>=date1 & invoice_date<=date2) %>%
    group_by(invoice_week=cut(invoice_date, "week"), store_id) %>%
    summarise(gross_margin=sum(gross_margin)) %>%
    group_by(store_id) %>%
    summarise(weekly_gross_margin=mean(gross_margin))
  # Add rownames as column to make joins easier
  wgm_by_dates$index <- as.numeric(row.names(wgm_by_dates))
  return(wgm_by_dates)
}
```

Comparative Dates

```r
# Filter data by test dates (2015-04-29 to 2015-07-21)
# and calculate weekly_gross_margin
wgm_comparative_dates <- wgm_by_dates(transactions, '2015-04-29', '2015-07-21')

# Create dataframe of weekly_gross_margins for treatment/control units
```

```
# TREATMENT
wgm_comparative_treatment <- left_join(match_matrix, wgm_comparative_dates, by=c('Treatment Store'='sto

# CONTROL
wgm_comparative_control1 <- left_join(match_matrix, wgm_comparative_dates, by=c('Control Store 1'='stor
wgm_comparative_control2 <- left_join(match_matrix, wgm_comparative_dates, by=c('Control Store 2'='stor
wgm_comparative_control <- rowMeans(data.frame(wgm_comparative_control1, wgm_comparative_control2))
# Create dataframe of treatment and control weekly_gross_margin
wgm_comparative <- data.frame(wgm_comparative_treatment, wgm_comparative_control)
names(wgm_comparative) <- c('Treatment', 'Control')
```

Test Dates

```
# Filter data by test dates (2016-04-29 to 2016-07-21)
# and calculate weekly_gross_margin
wgm_test_dates <- wgm_by_dates(transactions, '2016-04-29', '2016-07-21')

# Create dataframe of weekly_gross_margins for treatment/control units

# TREATMENT
wgm_test_treatment <- left_join(match_matrix, wgm_test_dates, by=c('Treatment Store'='store_id'))$weekl

# CONTROL
wgm_test_control1 <- left_join(match_matrix, wgm_test_dates, by=c('Control Store 1'='store_id'))$weekly
wgm_test_control2 <- left_join(match_matrix, wgm_test_dates, by=c('Control Store 2'='store_id'))$weekly
wgm_test_control <- rowMeans(data.frame(wgm_test_control1, wgm_test_control2))
# Create dataframe of treatment and control weekly_gross_margin
wgm_test <- data.frame(wgm_test_treatment, wgm_test_control)
names(wgm_test) <- c('Treatment', 'Control')
```

6. Calculate Lift

```
# Create df of increase in wgm by control, increase in wgm by treatment
lift_control <- wgm_test$Control/wgm_comparative$Control
lift_treatment <- wgm_test$Treatment/wgm_comparative$Treatment
lift <- data.frame(lift_control, lift_treatment)

# Calculate increase in weekly_gross_margin of treatment relative to control
lift_overall <- mean(lift$lift_treatment)/mean(lift$lift_control)
lift_west <- mean(lift$lift_treatment[1:5])/mean(lift$lift_control[1:5])
lift_central <- mean(lift$lift_treatment[6:10])/mean(lift$lift_control[6:10])
lift_overall
```

```
## [1] 1.42306
```

```
lift_west
```

```
## [1] 1.405746
```

```
lift_central
```

```
## [1] 1.44099
```

The calculated overall lift is approximately 46%, while the calculated lift for west region stores is approximately 43% and the calculated lift for central region stores is approximately 49%.

7. Calculate Statistical Significance

```
# Paired T-Test because the test conducted was matched pair
# Overall lift
t.test(lift$lift_treatment, lift$lift_control, paired=TRUE)
```

```
##
##  Paired t-test
##
## data:  lift$lift_treatment and lift$lift_control
## t = 6.4463, df = 9, p-value = 0.0001187
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.2693906 0.5606837
## sample estimates:
## mean of the differences
##               0.4150372
```

```
# Central lift
t.test(lift$lift_treatment[1:5], lift$lift_control[1:5], paired=TRUE)
```

```
##
##  Paired t-test
##
## data:  lift$lift_treatment[1:5] and lift$lift_control[1:5]
## t = 3.6189, df = 4, p-value = 0.02238
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.09428807 0.71574559
## sample estimates:
## mean of the differences
##               0.4050168
```

```
# West lift
t.test(lift$lift_treatment[6:10], lift$lift_control[6:10], paired=TRUE)
```

```
##
##  Paired t-test
##
## data:  lift$lift_treatment[6:10] and lift$lift_control[6:10]
## t = 5.452, df = 4, p-value = 0.005499
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.2085946 0.6415205
## sample estimates:
## mean of the differences
##               0.4250575
```

With a p-value of 0.0001156, there is sufficient evidence to reject the null hypothesis, that there is no difference in weekly gross margins between the control and treatment groups, in favor of the alternative hypothesis, that there is a difference in weekly gross margins between the control and treatment groups. The t-test estimated

lift is approximately 44% for all stores, 42% for west region stores and 46% for central region stores.

8. Summary

Planning the Analysis

Round Roasters, a coffee restaurant in the US, conducted a market test to determine the impacts of introducting a new menu and television marketing campaign. Because Round Roasters was interested in profitability and buying coffee follows a weekly cycle for customers, data was aggregated weekly and weekly gross margin was used as the target metric. Because Round Roasters collected data on their stores and transactions, a matched pair analysis was used. This matched pair analysis was conducted using the test period (April 29, 2016 to July 21, 2016) and the comparative period (April 29, 2015 to July 21, 2015).

Matching Treatent and Control Units

Determining Control Units

Two potential control variables were chosen for their logical validity and data availability: 1. square footage 2. average monthly sales

Per the correlation matrix below, average monthly sales correlates with gross margin, with a correlation coefficient of 0.995, while square footage does not correlate with gross margin, with a correlation coefficient of -0.029. Thus, average monthly sales was the only control variable used in the analysis.

```
##                  sum_gross_margin       sq_ft avg_month_sales
## sum_gross_margin       1.00000000 -0.02914714      0.99485333
## sq_ft                 -0.02914714  1.00000000     -0.04006262
## avg_month_sales        0.99485333 -0.04006262      1.00000000
```

Matching Treatment and Control Units

The following control units were matched to their respective treatment units, controlling for weekly sales and region of each store.

```
##    Treatment Store Control Store 1 Control Store 2
## 1             1664            8262            1964
## 2             1675            1857            7284
## 3             1696            7811            7334
## 4             1700            7484            6992
## 5             1712            8312            8162
## 6             2288            2409            3235
## 7             2293           12286           10518
## 8             2301            9639            9524
## 9             2322            8817            9438
## 10            2341           12019            2852
```

Analysis

A paired t-test was conducted between the increase in weekly gross sales between the test period (April 29, 2016 to July 21, 2016) and the comparative period (April 29, 2015 to July 21, 2015) for the treatment units and average of the control units. With a p-value of 0.0001156, there is sufficient evidence to reject the null

hypothesis, that there is no difference in weekly gross margin between the control and treatment groups, in favor of the alternative hypothesis, that there is a difference in weekly gross margin between the control and treatment groups. Per the bar graph of lift for each treatment-control unit pair below, the increase in incremental lift between treatment and control units is 44% for all stores. Because the increase in incremental lift for the new menu is statistically significant in both central region stores, at 46%, and west region stores, at 42%, it should be implemented in both central and west region stores.