API - 209 | Problem Set 8

Prof. Dan Levy

Due on Tuesday, October 25, 2022 at 10:00 am.

INSTRUCTIONS

To successfully complete this problem set, please follow these steps:

1. **Download this RMarkdown document file into your computer.**
2. **Insert all your answers into this document.** Guidance **here** on how to insert objects such as handwritten work or screenshot images in your answers.
3. **SAVE your work frequently**.
4. To make things easier to visualize in RStudio, you can set the view mode as “Visual” instead of as “Source” in the top left of your screen (just below the Save button).
5. Once your document is complete, please save it as a PDF by clicking the **KNIT** button.
6. Please submit an electronic copy of the PDF (and any separate requested files) to the Canvas course page.

   6.a) If you want to check a PDF version of this problem set before starting to work on it, you can always knit it. In fact, you can knit the document at any point.

   6.b) If you cannot Knit and it’s time to submit the problem set, submit the RMarkdown file and make an appointment with a member of the teaching team
7. Remember to consult the R resources from math camp, particularly the HKS R cheat sheet (available **here**, which contains many of the commands needed to answer the questions in this problem set.

IDENTIFICATION

1. Your information

```
Last Name: Chaturvedi
First Name: Shreya
```

2. Group Members (please list below the classmates you worked with on this problem set):

```
Group members: Mayank Sharma, Bharath Ram
```

3. Compliance with Harvard Kennedy School Academic Code: Do you certify that my work in this problem set complies with the Harvard Kennedy School Academic Code[1] (mark with an X below)?

[1] We abide by the Harvard Kennedy School Academic code (available here) for all aspects of the course. In terms of problem sets, unless explicitly written otherwise, the norms are the following: You are free (and encouraged) to discuss problem sets with your classmates. However, you must hand in your own unique written work and code in all cases. Any copy/paste of another’s work is plagiarism. In other words, you can work with your classmate(s), sitting side-by-side and going through the problem set question-by-question, but you must each type your own answers and your own code. For more details, please see syllabus.

[X] YES   [   ] NO

QUESTION 0 - RECORDING TIME

In an effort to understand better and more accurately the length of time that it takes you to complete problem sets, I would like to ask you to please fill in the form linked at the end of this problem set as accurately as possible. **As you go through this problem set, please keep track of the time you spend on each question and then record your time (in minutes).**

QUESTION 1 – TRASH WARRIOR

An urgent and unsolved environmental policy challenge is how to responsibly manage the waste generated in cities around the world. The World Bank estimates that global waste generation will rise to 3.4 billion tonnes by 2050 and governments vary widely in their attitudes, strategies and priorities towards this issue. Further, there is no consensus even in the world's richest cities on which public or private solutions work, and whether they can be successfully scaled.

MPA/ID graduate Lily Shen was inspired to tackle the overwhelming problem of open trash dumping in American cities by addressing some of the market failures that prevent small businesses in the Waste Management and Recycling industry from receiving more orders and achieving their full potential. In addition to her rigorous academic training, Ms. Shen is also an experienced Silicon Valley data scientist so it comes as no surprise that the company she founded embodies both her passion for social impact and a deep commitment to data-driven design.

Her social enterprise Trash Warrior is an on-demand waste management and janitorial service platform operating across 3000+ major cities in the United States. She describes their range of services simply as "*Uber for trash*" i.e., connecting waste management and recycling service providers with paying customers, and deploying digital solutions to diminish market frictions like search cost, information asymmetry, price discovery and others. Please watch this video from 2020 to learn more about Trash Warrior from Lily herself.

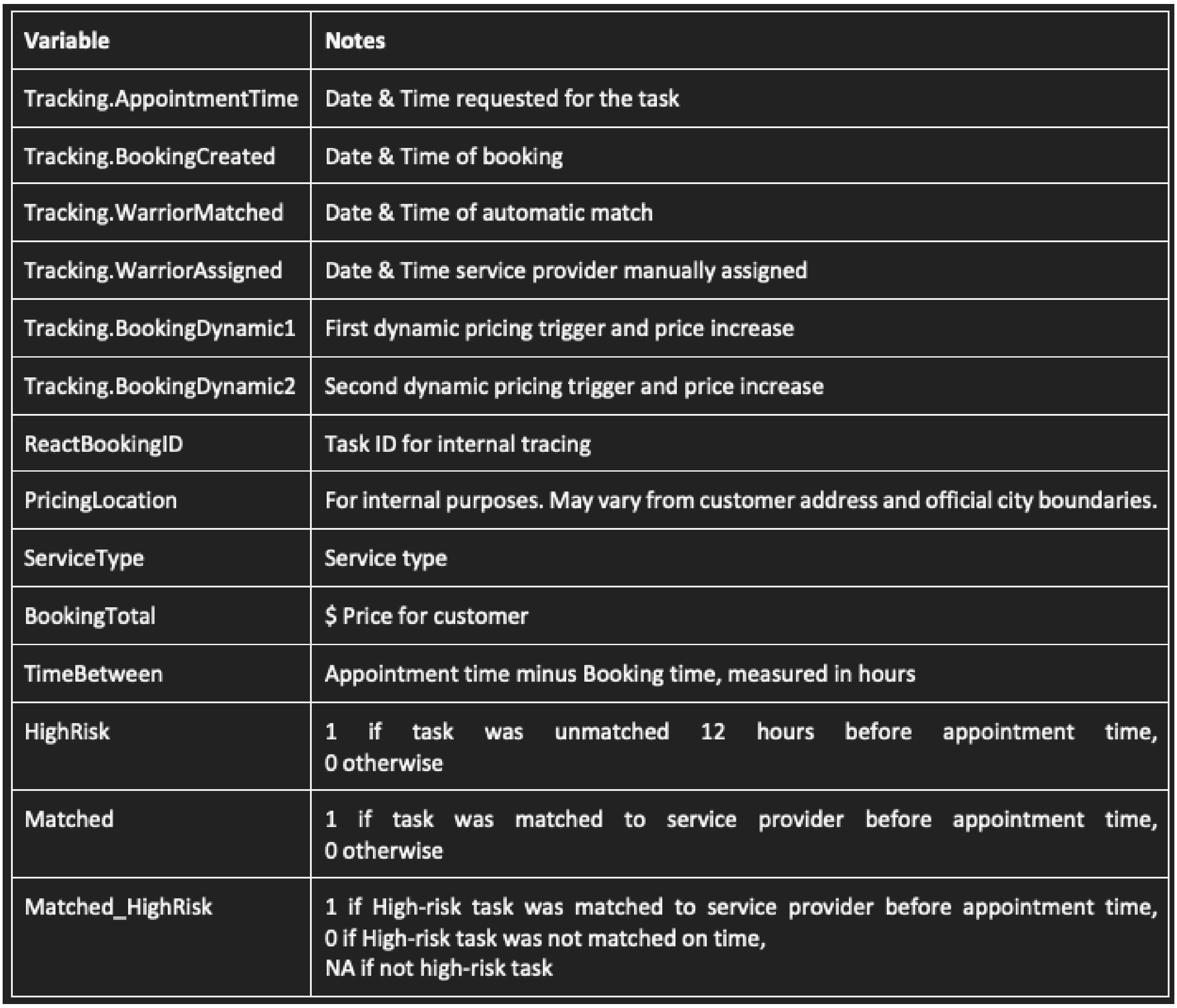
Problem Statement

In this problem set question you will focus on one aspect of Trash Warrior's business: **dynamic pricing**. Dynamic pricing is a market-clearing mechanism that many aggregators or platforms use. Trash Warrior uses dynamic pricing algorithms to attract service providers to unmatched tasks and to improve the overall match rate organically. If tasks are not organically matched, Trash Warrior must incur additional costs to manually tele-call service providers to encourage or 'assign' matches.

Using methods from API-209 you will analyze the results of a pilot test conducted in July-August 2022 and advise Trash Warrior on whether the new Dynamic Pricing Algorithm should be continued. The steps are explained sequentially below. This analysis presents both the benefits and challenges of a data-driven decision process, especially when the opportunity cost of waiting time is high. We hope you enjoy practicing statistical concepts from the course as well as your technical communication skills to advise Trash Warrior.

Data Preparation

Load the data set `tw.RData` using the `load()` command, and spend a few minutes understanding the variables and exploring the data set as you have practiced in previous problem sets.



Variable	Notes
Tracking.AppointmentTime	Date & Time requested for the task
Tracking.BookingCreated	Date & Time of booking
Tracking.WarriorMatched	Date & Time of automatic match
Tracking.WarriorAssigned	Date & Time service provider manually assigned
Tracking.BookingDynamic1	First dynamic pricing trigger and price increase
Tracking.BookingDynamic2	Second dynamic pricing trigger and price increase
ReactBookingID	Task ID for internal tracing
PricingLocation	For internal purposes. May vary from customer address and official city boundaries.
ServiceType	Service type
BookingTotal	$ Price for customer
TimeBetween	Appointment time minus Booking time, measured in hours
HighRisk	1 if task was unmatched 12 hours before appointment time, 0 otherwise
Matched	1 if task was matched to service provider before appointment time, 0 otherwise
Matched_HighRisk	1 if High-risk task was matched to service provider before appointment time, 0 if High-risk task was not matched on time, NA if not high-risk task

Confirm that your data set has 2228 rows.

```
load("/Users/shreyachaturvedi/Downloads/API209/PS8/tw.RData")
```

Answer:

Please enter " Done" in this field once you have confirmed it.

Done

The Business Problem

Create a new data set for baseline exploratory analysis. From the original data set filter only those tasks that were booked between Apr-June 2022 in pricing location Houston.

Suggested R code to filter dates: `filter(between(lubridate::date(Tracking.BookingCreated), as.Date("01-04-2022", "%d-%m-%Y"), as.Date("30-06-2022", "%d-%m-%Y")))`

Confirm that this new data set has **374** rows.

```
# Enter only code here.
baselinedata <- tw %>%
  filter(between(lubridate::date(Tracking.BookingCreated), as.Date("01-04-2022", "%d-%m-%Y"), as.Date("30
  filter(PricingLocation == "Houston")
```

Answer:

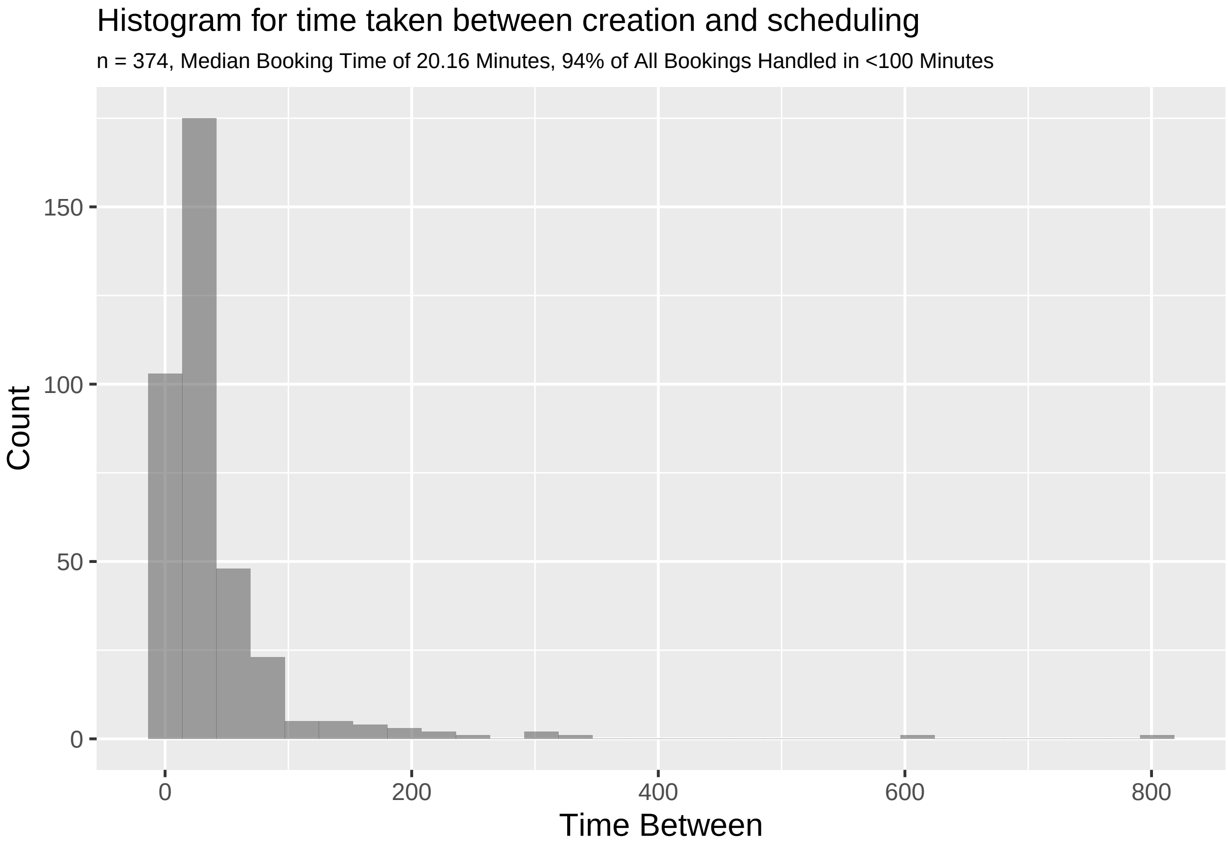
Please enter " Done" in this field once you have confirmed it.

Done

---

1. Start by understanding the distribution of the time between when the booking is made and when the task is scheduled. This is an important constraint for Trash Warrior because a service provider must be matched to a customer's task within this time. If most tasks tend to be booked at short notice it could be difficult for the market to 'clear'. Make a presentation-ready histogram of the variable `TimeBetween`. Display your key takeaway in the graph's subtitle and add any other visual elements that would help the reader.

```
# Enter only code here.
baselinedata %>%
ggplot(aes(x = TimeBetween, alpha = 0.9)) +
geom_histogram() +
labs(x="Time Between",
y = "Count",
title="Histogram for time taken between creation and scheduling",
subtitle="n = 374, Median Booking Time of 20.16 Minutes, 94% of All Bookings Handled in <100 Minutes") +
theme(plot.title=element_text(size=12, hjust=0),
plot.subtitle=element_text(size=8,hjust=0),
plot.caption= element_text(size=7),
axis.title.x=element_text(size=12,hjust=0.5),
axis.title.y=element_text(size=12,hjust=0.5)) +
theme(legend.position = "none",legend.title = element_blank())
```



2. Now calculate and report the monthly match rate for the following in a single table:

- % of all tasks matched, reported separately by the month of booking
- % of high-risk tasks matched, reported separately by the month of booking

```
# Enter only code here.
test <- baselinedata %>%
  mutate(month = format(Tracking.BookingCreated, "%m"), year = format(Tracking.BookingCreated, "%Y")) %>%
  mutate(Matched01 = ifelse(Matched,1,0)) %>%
  mutate(HRMatched01 = ifelse(Matched_HighRisk,1,0)) %>%
  group_by(month) %>%
  mutate(matched = mean(Matched01)) %>%
  mutate(hrmatched = mean(HRMatched01, na.rm = TRUE)) %>%
  select(month, hrmatched, matched) %>%
  ungroup() %>%
  unique() %>%
   gt() %>%
  tab_header(
    title = "Month-Wise Trends",
  ) %>%
  cols_label(
    matched = "Matched",
    hrmatched = "High Risk Matched",
    month = "Month"
  )

  test
```

Month-Wise Trends

Month	High Risk Matched	Matched
04	0.6896552	0.8439306
05	0.6111111	0.8018868
06	0.5111111	0.7684211

```
# Insert here the code for your results table.
```

3. What is the trend over time in both metrics you reported in the previous question? Briefly explain the consequences in 1-2 sentences each for:

- Trash Warrior's business costs
- **[Optional]** For other stakeholders such customers and service providers who use the platform and city residents in general

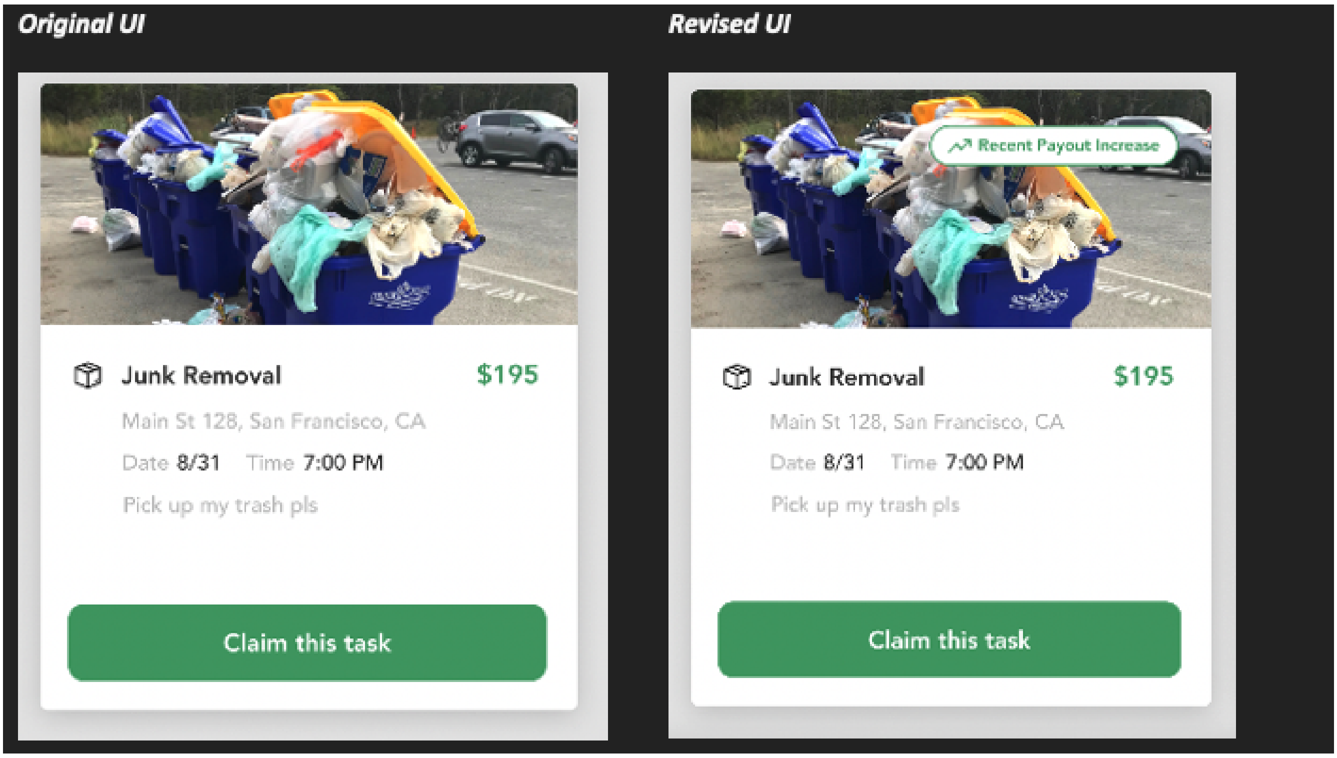
Answer:

Please insert your answer here.

As we can see in the table above, the trend in both matched and high risk matched metrics is downward. That is, both metrics are consistently dropping over time. As a consequence, fewer requests are matched with service providers.

Houston Pilot

Trash Warrior has a Dynamic Pricing Algorithm as well as several UI/UX design features that facilitate market-clearing. In July 2022 they proposed a few changes to both. The algorithm was edited such that the first dynamic pricing trigger would be issued 12 hours before the Appointment Time (earlier it was not triggered until T-5 hours) and the subsequent triggers were adjusted accordingly. The interface was also re-designed to make these tasks more visible and attractive to service providers.



Junk Removal $195
Main St 128, San Francisco, CA
Date 8/31 Time 7:00 PM
Pick up my trash pls

Junk Removal $195
Main St 128, San Francisco, CA
Date 8/31 Time 7:00 PM
Pick up my trash pls

These changes were gradually rolled out in different locations for pilot-testing and we will **use data from before and after the roll-out to assess effectiveness.**

The changes were first rolled out in Houston on July 21, 2022. Prepare a data set to analyze the results of the Houston pilot by following these instructions.

- From the original data set you imported, filter to keep only tasks booked in Pricing Location Houston between 01 July 2022-10 August 2022
- Create a new factor variable to label tasks booked between 01 July - 20 July as “Pre” and those between 21 July - 10 August as “Post”. Set “Pre” as the first factor level to make subsequent data analysis easier.
- Assume that a Balance Test performed on the characteristics of tasks available in this data set shows that Pre & Post groups are comparable i.e. the means are not statistically different.

Confirm that there are 65 observations in Pre and 63 observations in the Post group.

```
# Enter only code here.
pilotdata <- tw %>%
  filter(between(lubridate::date(Tracking.BookingCreated), as.Date("01-07-2022", "%d-%m-%Y"), as.Date("1
  filter(PricingLocation == "Houston") %>%
  mutate(Pre = ifelse(between(lubridate::date(Tracking.BookingCreated), as.Date("01-07-2022", "%d-%m-%Y")
```

Answer:

Please enter ” Done” in this field once you have confirmed it.

Done

---

4. Perform a t-test for the difference in match rate for all tasks between the two groups. Interpret the results.

```
# Enter only code here.
ttest <- pilotdata %>%
  mutate(Matched01 = ifelse(Matched,1,0)) %>%
  mutate(PreMatched = ifelse(Pre == 1, Matched01, NA)) %>%
  mutate(PostMatched = ifelse(Pre == 0, Matched01, NA)) %>%
  select(PreMatched, PostMatched)

t.test(ttest$PreMatched,ttest$PostMatched, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  ttest$PreMatched and ttest$PostMatched
## t = -0.26032, df = 125.98, p-value = 0.795
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.1848534  0.1418741
## sample estimates:
## mean of x mean of y
## 0.6769231 0.6984127
```

Answer:

Please insert your answer here.

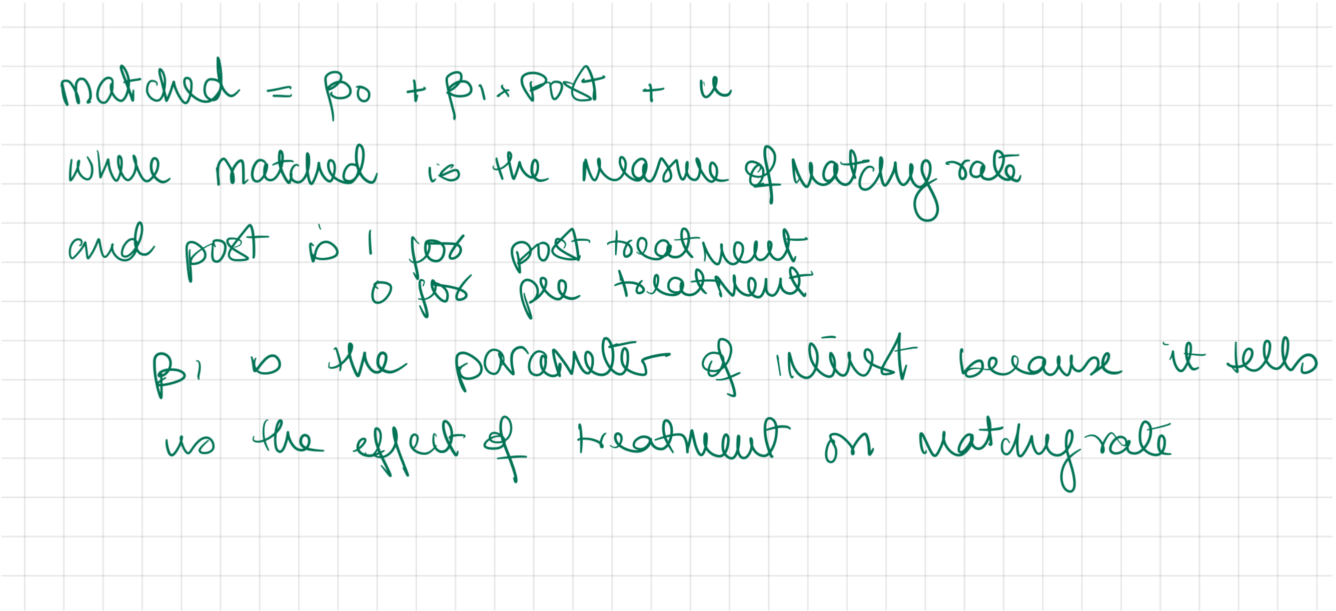
We fail to reject that there is any difference between the pre and post treatment groups.

---

5. Write a regression equation in the form of a Population Regression Function (PRF) to estimate the same result and circle/highlight/indicate the terms or parameters you would use to estimate the effect of the ruleset change.

Answer:

Please insert your answer here.



$$matched = \beta_0 + \beta_1 \times Post + u$$

where matched is the measure of matching rate

and post is 1 for post treatment
0 for pre treatment

β_1 is the parameter of interest because it tells us the effect of treatment on matching rate

---

6. Run this regression. Is the coefficient of interest equal to the difference between group means reported in the t-test? Interpret the result, p-value and statistical significance.

```
# Enter only code here.
pilotdata <- pilotdata %>%
  mutate(Matched01 = ifelse(Matched,1,0))

model <- lm(Matched01 ~ Pre, pilotdata)
summary(model)
```

```
##
## Call:
## lm(formula = Matched01 ~ Pre, data = pilotdata)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.6984 -0.6769  0.3016  0.3231  0.3231
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.69841    0.05884   11.87   <2e-16 ***
## Pre         -0.02149    0.08257   -0.26    0.795
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4671 on 126 degrees of freedom
## Multiple R-squared:  0.0005372,  Adjusted R-squared:  -0.007395
## F-statistic: 0.06773 on 1 and 126 DF,  p-value: 0.7951
```

```
# Insert here the code for your results table.
```

Answer:

Please insert your answer here.

We get the same result as we do in the ttest, with the pre matching rate being 0.68 and post matching rate neing 0.70. The p values in both cases is 0.795, which means that we fail to reject the null hypothesis.

---

7. Can Trash Warrior rely on this regression result to decide whether the new Dynamic Pricing Algorithm works? Explain why/why not.

Answer:

Please insert your answer here.

I don't think that trash warriors can rely on this regression to decide whether the pricing works as a simple pre post analysis doesnt give us a counterfactual - What if across the board some external factors caused the rate to drop to 0.5, but because of this algorithm it remained at 0.7 in Houston? In this case the impact of the algorithm would definitely not be zero.

All Cities Pilot

On 4th August 2022 the pilot was extended to all of Trash Warrior's locations in the United States, so you decide to take advantage of the larger sample. From the original data set you imported, you have filtered to keep only tasks booked between 21 July - 31 August in all Pricing Locations that are not Houston. Your data set in this case has 1254 and 472 observations in Pre and Post groups respectively.

8. A larger sample is generally better, but you remember from API-209 that statistical power also depends on α, β and MDE. Just thinking about that confusing topic gives you a headache, so you decide to pause and think about practical significance instead. Write a short Slack message to David Chang (Trash Warrior's Product Manager in-charge of the pricing algorithms) asking about the threshold for practical significance. Avoid statistical jargon if possible.

```r
allcitiespilot <- tw %>%
  filter(between(lubridate::date(Tracking.BookingCreated), as.Date("21-07-2022", "%d-%m-%Y"), as.Date("31
  filter(PricingLocation != "Houston") %>%
  mutate(Post = ifelse(between(lubridate::date(Tracking.BookingCreated), as.Date("21-07-2022", "%d-%m-%Y'
```

Answer:

Please insert your answer here.

Hi David,

Hope everything is going great! I was just going over some of the data for our all cities pilot and had a quick question for you: At approximately how much change (with respect to the base value) of matching rate would you consider the algorithm to be a success?

Shreya

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9. David replies "Honestly, this intervention is so cheap that I'd be ok with a small effect like we saw in Houston. Even a small but real improvement is a win for users. Also, we're constantly innovating and experimenting with product features, so the investors and industry as a whole have a higher tolerance for false positives/false negatives on statistical tests…maybe you want to keep that in mind?" Does David care about statistical significance? Does David care about practical significance? Use phrases from his message to support your answer.

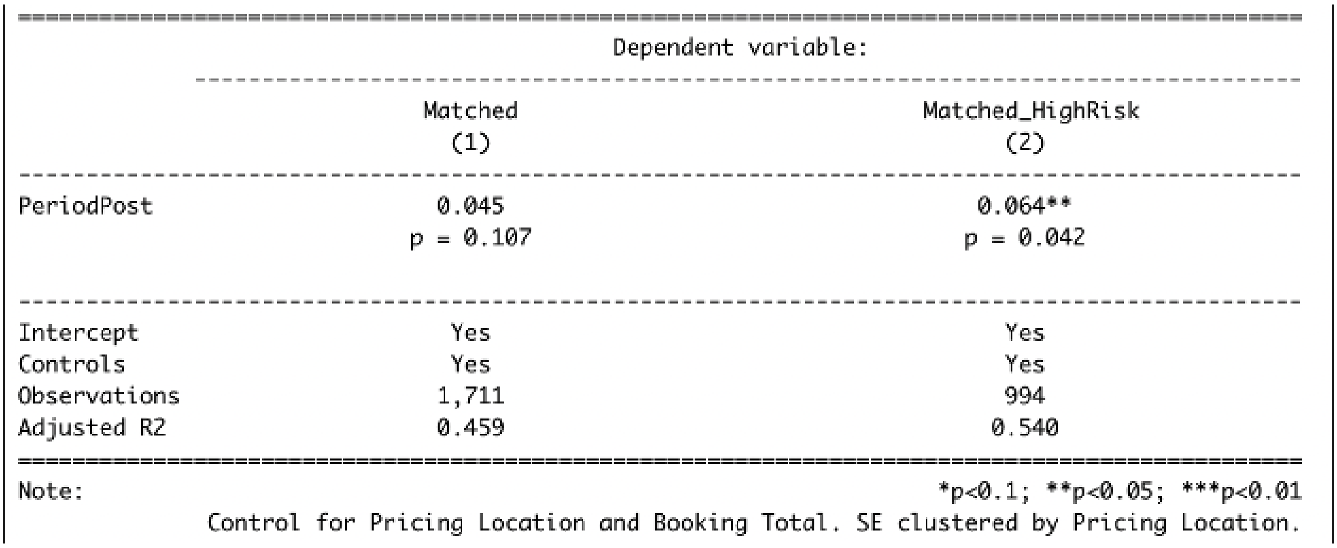
Answer:

Please insert your answer here.

This basically means that David is not as concerned with statistical significance ("higher tolerance for false positives/false negatives on statistical tests"). Since the cost of the intervention is low, even a small magnitude of change is practically significant - David's main concern.

---

10. While you were chatting with David, your Enthusiastic Friend went ahead and ran the regressions on the new data set you have created above. Assuming that you can trust their work, interpret the main results from their table below. Remember to look at the dependent and independent variables, sample size, coefficient size and statistical significance.



```
==========================================================================================
                                        Dependent variable:
                          ----------------------------------------------------------------
                                  Matched                          Matched_HighRisk
                                    (1)                                  (2)
------------------------------------------------------------------------------------------
PeriodPost                         0.045                              0.064**
                                 p = 0.107                           p = 0.042

------------------------------------------------------------------------------------------
Intercept                           Yes                                  Yes
Controls                            Yes                                  Yes
Observations                       1,711                                 994
Adjusted R2                        0.459                                0.540
==========================================================================================
Note:                                                          *p<0.1; **p<0.05; ***p<0.01
             Control for Pricing Location and Booking Total. SE clustered by Pricing Location.
```

Answer:

Please insert your answer here.

The treatment has some impact on both matched and high risk matched rates. In the case of matched, there is approximately a 5% increase in matched rate as a result of the algorithm but this is not statistically significant at 95% level. In the case of high risk matched, there is approximately a 6% increase in matched rate which is significant at a 5%. Some things to note are:

1. The sample size for high risk matched is about half of the total matched rate, which may have reduced our power.
2. While the effects are of similar magnitude, one is statistically significant and one isn't. However, from our interaction with David, both would be of interest or practical significance since the cost of the intervention is pretty low.

11. Lily Shen mentions to you that the Board members are concerned about the declining match rate and that she wants to update them about the new Dynamic Pricing Algorithm. Considering all the pilot tests done, additional information received from David Chang, and understanding that you need to strike a balance between statistical validity and business needs in a fast-paced environment, would you advise her to continue with the new algorithm or not to? Send your clear recommendation and reasoning to the CEO in 1 paragraph. Avoid technical jargon since she may forward your email to the Board!

Answer:

Please insert your answer here.

Hi Lily,
I think it would be a good idea to continue testing out the algorithm for a couple of reasons:

1. We have seen improvement in the matching rate and high risk matching rate in our pilots on a country level.

2. While the magnitude of the difference is not very large, these algorithms are not expensive to implement so it is low hanging fruit for us to implement.

3. As we expand the algorithm use over longer periods of time, we will get more data that helps us definitely assess the impact on matching rate.

   Please let me know if you'd like to discuss further.

   Best,
   Shreya

NOTE: Please remember to **record the time** it took you to complete this question.

QUESTION 2 – ESTIMATING IMPACTS ON STEPS, PART II

In your previous problem set, you were asked to describe what you would do with a data set to estimate the effects of a program to increase the number of steps people take a day. Most answers included a comparison of means between the treatment and control groups or a bivariate regression, and concluded that the program had a statistically significant effect of 2,793 steps. The goal of this problem set question is to help you see the importance of examining and visualizing the data **before** running any regressions.

1. If properly conducted, the RCT helps ensure that the treatment and control groups are equivalent at baseline. Is there evidence in the data that supports this claim? To answer this question, compare the average number of steps at baseline between treatment and control groups. Is the difference between the two groups statistically significant? What does this say about the credibility of this RCT?

```
# Enter only code here.
steps <- read_csv("Steps.csv")
bt <- balance_table(steps,"treatment")
names(bt) <- c("Variable","Control Group Mean","Treatment Group Mean","P Value")
bt
```

```
## # A tibble: 3 x 4
##   Variable      `Control Group Mean` Treatment Gr~1 P Valu~2
##   <chr>                        <dbl>          <dbl>    <dbl>
## 1 BaselineSteps               75512.         69887. 1.06e-11
## 2 PostSteps                   99147.         96316. 1.14e- 3
## 3 StepChange                  23635.         26429. 4.47e-25
## # ... with abbreviated variable names
## #   1: `Treatment Group Mean`, 2: `P Value`
```

```
# Insert here the code for your results table.
```

Answer:

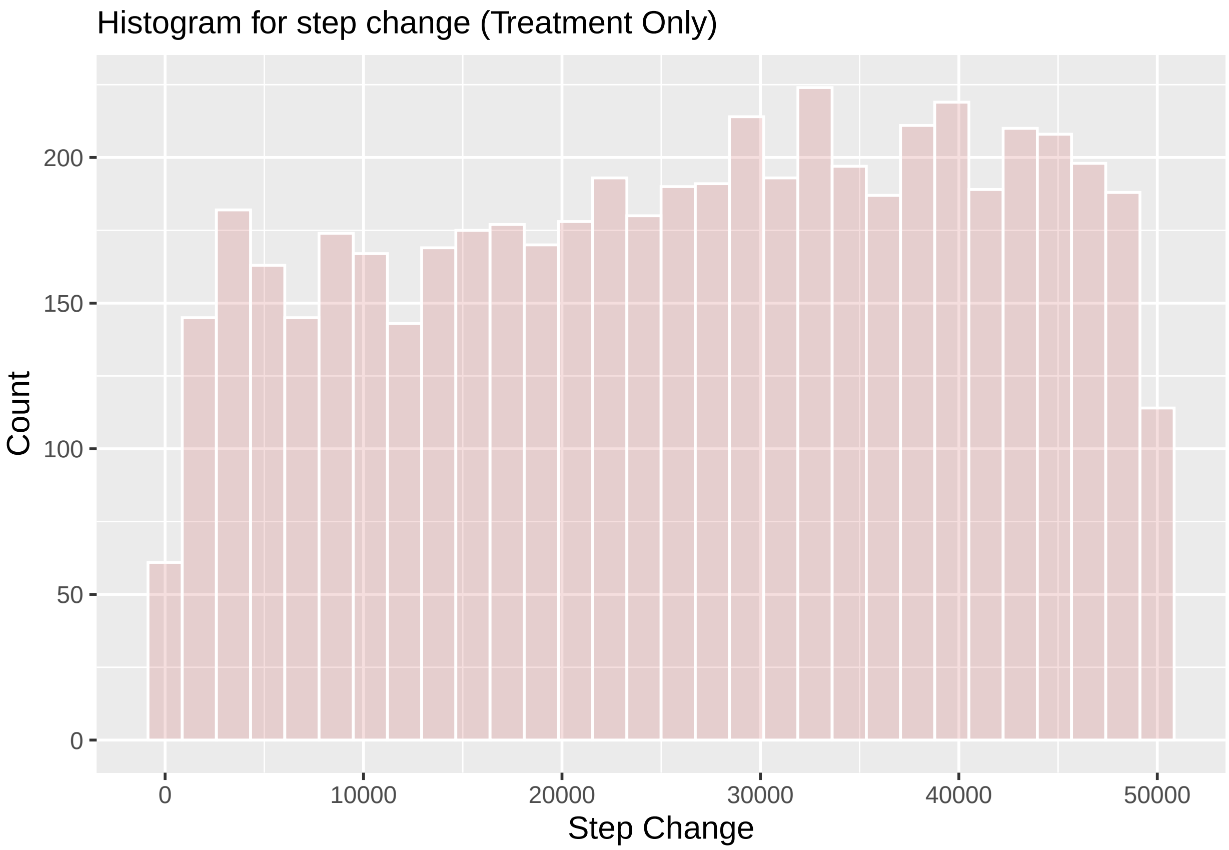
Please insert your answer here.

The difference at baseline in the number of steps between the treatment and the control groups is large and statistically significant (extremely small p value). This indicates to me that the groups are not balanced at the outset, and raises questions in my mind regarding the validity of this experiment.

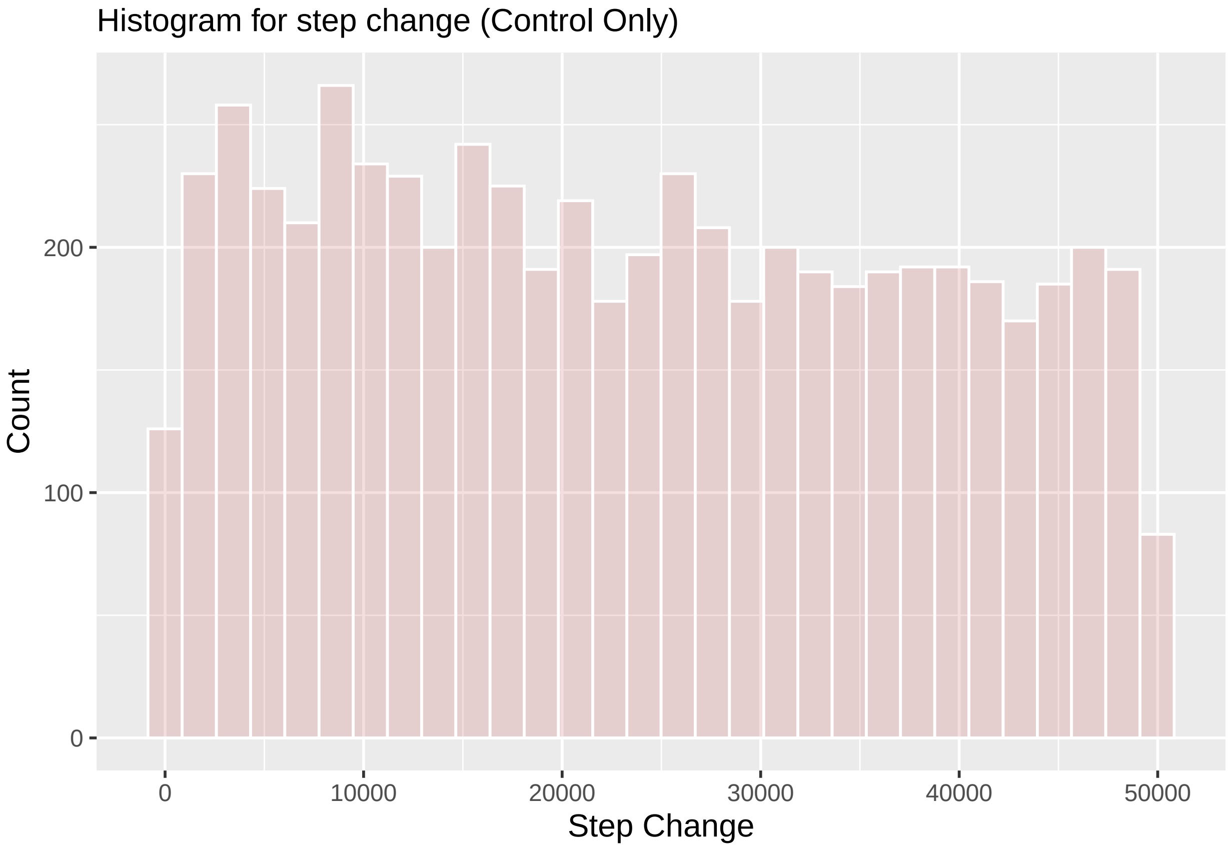
---

2. Now let's focus on the outcome variable (`StepChange`), which measures the number of steps that people took in the final week of the program. What would you expect to be the distribution of this variable? Create a histogram of this variable. Is this what you expected? What does this say about the credibility of the outcome variable used in this RCT?

```
# Enter only code here.
stept <- steps %>%
  filter(treatment == 1)
stepc <- steps %>%
  filter(treatment == 0)

plott <- ggplot(stept , aes(x = StepChange)) +
geom_histogram(alpha = 0.2, color ="white",fill ="indianred") +
labs(x="Step Change",
y = "Count",
title="Histogram for step change (Treatment Only)") +
theme(plot.title=element_text(size=12, hjust=0),
plot.subtitle=element_text(size=8,hjust=0),
plot.caption= element_text(size=7),
axis.title.x=element_text(size=12,hjust=0.5),
axis.title.y=element_text(size=12,hjust=0.5)) +
theme(legend.position = "none",legend.title = element_blank())

plotc <- ggplot(stepc , aes(x = StepChange)) +
geom_histogram(alpha = 0.2, color ="white",fill ="indianred") +
labs(x="Step Change",
y = "Count",
title="Histogram for step change (Control Only)") +
theme(plot.title=element_text(size=12, hjust=0),
plot.subtitle=element_text(size=8,hjust=0),
plot.caption= element_text(size=7),
axis.title.x=element_text(size=12,hjust=0.5),
axis.title.y=element_text(size=12,hjust=0.5)) +
theme(legend.position = "none",legend.title = element_blank())

plott
```



```
plotc
```



Answer:

Please insert your answer here.

I expect the distribution of outcome variable to be normal for both treatment and controls, but here the outcome variables are more uniformly distributed. Further, the outcome variable is strongly correlated with the baseline steps - which, as we established, is not balanced between treatment and control groups. The variable distribution also skews differently for both treatment and control groups. This is not ideal in an RCT.

---

3. What lessons do you draw from this exercise as you think about the next time you are about to start running regressions on a data set?

Answer:

Please insert your answer here.

I think the most important takeaway here is to ensure balance in the treatment and control variables before running any regressions. Further, it is important to check if these variables have any correlation with other variables in our dataset.

---

4. **[Optional]** It turns out the data set you analyzed is a masked version of a data set that was used to produce a highly influential paper that argued that dishonesty can be reduced by asking people to sign a statement of honest intent before providing information (i.e., at the top of a document) rather than after providing information (i.e., at the bottom of a document). The paper was based on a field experiment conducted by an auto insurance company in the southeastern United States. Customers were asked to report the current odometer reading of up to four cars covered by their policy. They were randomly assigned to sign a statement indicating, "*I promise that the information I am providing is true*" either at the top or bottom of the form. Customers assigned to the 'sign-at-the-top' condition reported driving 2,400 more miles than those assigned to the 'sign-at-the-bottom' condition. This was seen as evidence that signing at the top could be a cheap and effective way of reducing dishonesty. The data set you analyzed last week is the one used in this paper except that we referred to the outcome as steps taken rather than miles driven, and we

focused on the odometer reading of the first car only (hence the impact you found was slightly different than the one reported in the paper). The analysis you conduced above plus some additional analyses provided compelling evidence that the findings from the paper were not real and were partially based on fake data. This posting goes over many of the details. The authors of the paper retracted the original publication, and several of them issued personal replies to the posting. This controversy raised some important issues about data analysis, reproducibility of research findings, detection of fake data, and admission of error. Feel free to comment below and/or on our Slack workspace (using the # problem-sets channel) your views about any of these issues.

Answer:

Please insert your answer here.

NOTE: Please remember to **record the time** it took you to complete this question.

QUESTION 3 – ONLINE MODULES

Background: You will be asked to watch two short modules and answer some questions in a quiz. The quiz results will give me information about overall performance of the class that I will use to prepare for class; your individual performance in the quiz will be registered in the system but will not count towards your grade in any way.

To get full credit for this question, you need to engage with the module and complete the quiz. Please make sure you submit your answers at the end of the quiz/survey so that they are registered.

The modules is available here:

1. **Omitted Variable Bias**: https://canvas.harvard.edu/courses/109224/pages/1-omitted-variable-bias?module_item_id=1176571
2. **R2 and Standard Errors**: https://canvas.harvard.edu/courses/109224/pages/1-r-squared?module_item_id=1176574

Answer:

Please enter "Done" in this field once you have concluded *BOTH* modules.

Done

NOTE: Please remember to **record the time** it took you to complete this question.

TIME USE

Please enter in the form linked below the time you spent on each question.

This information will only be used for teaching improvements; **please be candid** and report the time (in **MINUTES**) spent in each question.

The form is available here:

https://forms.gle/n9Z8EYQRw8U4nCaX9

Please enter “Done” in this field once you have completed the form.

This is a copy of your code.

```
.answer-box {
  background-color: LemonChiffon;
}
knitr::opts_chunk$set(echo = TRUE)
knitr::opts_chunk$set(options(width = 60))
knitr::opts_chunk$set(class.output = "bg-warning")

packages <- c('haven','dplyr', 'ggplot2', 'reshape2', 'tidyverse', 'pracma',
              'lubridate', 'scales', 'ggthemes', 'gt','RCT')
to_install <- packages[!(packages %in% installed.packages()[,"Package"])]
if(length(to_install)>0) install.packages(to_install,
                                          repos='http://cran.us.r-project.org')
lapply(packages, require, character.only=TRUE)


Last Name: Chaturvedi
First Name: Shreya
Group members: Mayank Sharma, Bharath Ram
                             [X] YES                [   ] NO
load("/Users/shreyachaturvedi/Downloads/API209/PS8/tw.RData")
# Enter only code here.
baselinedata <- tw %>%
  filter(between(lubridate::date(Tracking.BookingCreated), as.Date("01-04-2022", "%d-%m-%Y"), as.Date("30
  filter(PricingLocation == "Houston")
# Enter only code here.
baselinedata %>%
ggplot(aes(x = TimeBetween, alpha = 0.9)) +
geom_histogram() +
labs(x="Time Between",
y = "Count",
title="Histogram for time taken between creation and scheduling",
subtitle="n = 374, Median Booking Time of 20.16 Minutes, 94% of All Bookings Handled in <100 Minutes") +
theme(plot.title=element_text(size=12, hjust=0),
plot.subtitle=element_text(size=8,hjust=0),
plot.caption= element_text(size=7),
axis.title.x=element_text(size=12,hjust=0.5),
axis.title.y=element_text(size=12,hjust=0.5)) +
theme(legend.position = "none",legend.title = element_blank())
# Enter only code here.
test <- baselinedata %>%
  mutate(month = format(Tracking.BookingCreated, "%m"), year = format(Tracking.BookingCreated, "%Y")) %>%
  mutate(Matched01 = ifelse(Matched,1,0)) %>%
  mutate(HRMatched01 = ifelse(Matched_HighRisk,1,0)) %>%
  group_by(month) %>%
  mutate(matched = mean(Matched01)) %>%
  mutate(hrmatched = mean(HRMatched01, na.rm = TRUE)) %>%
  select(month, hrmatched, matched) %>%
  ungroup() %>%
  unique() %>%
   gt() %>%
  tab_header(
    title = "Month-Wise Trends",
  ) %>%
  cols_label(
    matched = "Matched",
    hrmatched = "High Risk Matched",
    month = "Month"
  )

  test
```

```
# Insert here the code for your results table.

# Enter only code here.
pilotdata <- tw %>%
  filter(between(lubridate::date(Tracking.BookingCreated), as.Date("01-07-2022", "%d-%m-%Y"), as.Date("10
  filter(PricingLocation == "Houston") %>%
  mutate(Pre = ifelse(between(lubridate::date(Tracking.BookingCreated), as.Date("01-07-2022", "%d-%m-%Y")
# Enter only code here.
ttest <- pilotdata %>%
  mutate(Matched01 = ifelse(Matched,1,0)) %>%
  mutate(PreMatched = ifelse(Pre == 1, Matched01, NA)) %>%
  mutate(PostMatched = ifelse(Pre == 0, Matched01, NA)) %>%
  select(PreMatched, PostMatched)

t.test(ttest$PreMatched,ttest$PostMatched, var.equal = FALSE)

# Enter only code here.
pilotdata <- pilotdata %>%
  mutate(Matched01 = ifelse(Matched,1,0))

model <- lm(Matched01 ~ Pre, pilotdata)
summary(model)

# Insert here the code for your results table.

allcitiespilot <- tw %>%
  filter(between(lubridate::date(Tracking.BookingCreated), as.Date("21-07-2022", "%d-%m-%Y"), as.Date("31
  filter(PricingLocation != "Houston") %>%
  mutate(Post = ifelse(between(lubridate::date(Tracking.BookingCreated), as.Date("21-07-2022", "%d-%m-%Y'
# Enter only code here.
steps <- read_csv("Steps.csv")
bt <- balance_table(steps,"treatment")
names(bt) <- c("Variable","Control Group Mean","Treatment Group Mean","P Value")
bt
# Insert here the code for your results table.

# Enter only code here.
stept <- steps %>%
  filter(treatment == 1)
stepc <- steps %>%
  filter(treatment == 0)

plott <- ggplot(stept , aes(x = StepChange)) +
geom_histogram(alpha = 0.2, color ="white",fill ="indianred") +
labs(x="Step Change",
y = "Count",
title="Histogram for step change (Treatment Only)") +
theme(plot.title=element_text(size=12, hjust=0),
plot.subtitle=element_text(size=8,hjust=0),
plot.caption= element_text(size=7),
axis.title.x=element_text(size=12,hjust=0.5),
axis.title.y=element_text(size=12,hjust=0.5)) +
theme(legend.position = "none",legend.title = element_blank())

plotc <- ggplot(stepc , aes(x = StepChange)) +
geom_histogram(alpha = 0.2, color ="white",fill ="indianred") +
labs(x="Step Change",
y = "Count",
title="Histogram for step change (Control Only)") +
theme(plot.title=element_text(size=12, hjust=0),
plot.subtitle=element_text(size=8,hjust=0),
plot.caption= element_text(size=7),
axis.title.x=element_text(size=12,hjust=0.5),
axis.title.y=element_text(size=12,hjust=0.5)) +
theme(legend.position = "none",legend.title = element_blank())

plott
plotc
```