在 R Markdown 文档中使用中文

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目录

1 引言

中文 LaTeX 文档并非难题。当然这句话得站在巨人 CTeX 的肩膀上才能说，它让我们只需要一句

```
\documentclass{ctexart} % 或者 ctexrep/ctexbook
```

或者

```
\usepackage{ctex}
```

就轻松搞定中文 LaTeX 排版问题。

2 字体和选项

LaTeX 包**ctex**支持若干种字体选项，如果你是 **ctex** 老用户，请注意这里我们要求的最低版本是 2.2，你可能需要升级你的 LaTeX 包。从版本 2.0 开始，**ctex** 支持根据不同操作系统自动选择中文字体，简直是为人类进步作出了巨大贡献，我们再也不必费尽口舌向用户解释“啊，你用 Windows 啊，那么你该使用什么字体；啊，你用 Mac 啊，又该如何如何”。

下面的 YAML 元数据应该能满足多数用户的需求，主要设置两项参数：文档类为 `ctexart`（当然也可以是别的类），输出格式为 `rticles::ctex`，其默认 LaTeX 引擎为 XeLaTeX（真的，别纠结你的旧爱 PDFLaTeX 了）。

```
---
documentclass: ctexart
output: rticles::ctex
---
```

rticles::ctex 的参数都是普通的 pdf_document 参数，参见文档 **rmarkdown** 包的文档，这里就不赘述了。

Windows 和 Mac 用户应该都已经有自带的中文字体了。Linux 用户可以考虑 Fandol 字体，它号称是免费的，不过我们也没太搞清楚它的来头。如果你不想操心这些问题，我们强烈建议你卸载你当前的 LaTeX 套装（TeX Live 或 MiKTeX 或 MacTeX），换上 TinyTeX，一切将会自动化搞定。

```
devtools::install_github(c('rstudio/rmarkdown', 'yihui/tinytex'))
tinytex::install_tinytex()
# 问题 1.1:
```

```
# 问题 1.1: BigBangTheory. (Attached Data: BigBangTheory)
bigbang <- read.csv("data/BigBangTheory.csv")
# 计算观众数量的最小值和最大值，计算均值、中位数和众数，计算第一和第三四分位数
min_viewers <- min(bigbang$Viewers..millions., na.rm = TRUE)
max_viewers <- max(bigbang$Viewers..millions., na.rm = TRUE)
mean_viewers <- mean(bigbang$Viewers..millions., na.rm = TRUE)
median_viewers <- median(bigbang$Viewers..millions., na.rm = TRUE)
mode_viewers <- modeest::mfv(bigbang$Viewers..millions., na.rm = TRUE)
first_quartile <- quantile(bigbang$Viewers..millions., 0.25, na.rm = TRUE)
third_quartile <- quantile(bigbang$Viewers..millions., 0.75, na.rm = TRUE)
# 查看分析结果
result1 <- data.frame(最小值 = min_viewers, 最大值 = max_viewers, 均值 = mean_viewers, 中位数 = medi
result2 <- data.frame(众数 = mode_viewers)
result1
```

```
#>     最小值 最大值     均值 中位数 第一四分位数 第三四分位数
#> 25%   13.3   16.5 15.04286     15          14.1           16
```

```
result2
```

```
#>   众数
#> 1 13.6
#> 2 14.0
#> 3 16.1
#> 4 16.2
```

问题 1.2

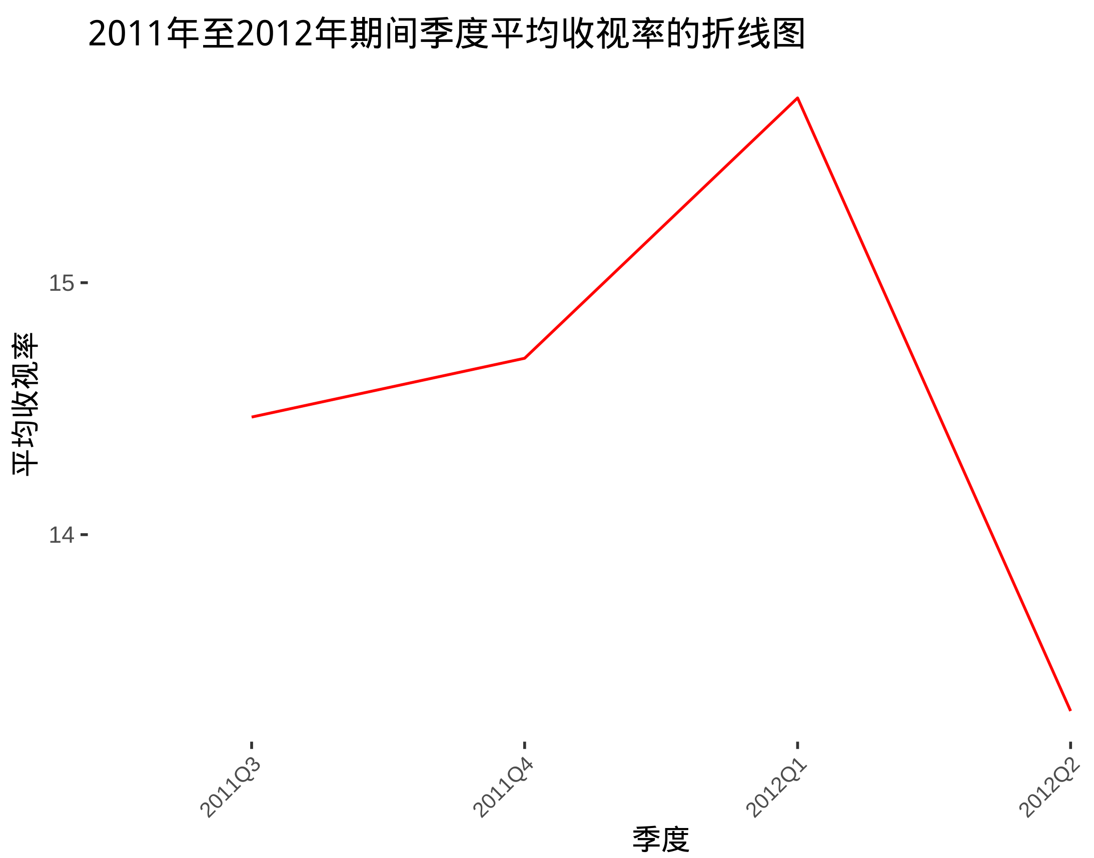
```r
# 问题 1.2::has viewership grown or declined over the 2011-2012 season? Discuss.
library(tidyverse)
library(lubridate)

# 读取数据
df <- read.csv("data/BigBangTheory.csv", stringsAsFactors = FALSE, fileEncoding = "UTF-8")

# 将 Air.Date 列转换为日期格式
df$Air.Date <- mdy(df$Air.Date)

# 提取年份和季度作为标识
df$Year <- year(df$Air.Date)
df$Quarter <- quarter(df$Air.Date)

# 筛选出 2011 到 2012 年的数据
df_subset <- df %>% filter(Year >= 2011 & Year <= 2012)

# 按照年份和季度分组，并计算平均收视率
quarterly_data <- df_subset %>%
  group_by(Year, Quarter) %>%
  summarise(ave_viewer = mean(Viewers..millions.),.groups = "drop") %>%
  mutate(Quarter_Label = paste(Year, "Q", Quarter, sep = ""))

print(quarterly_data)
```

```
#> # A tibble: 4 x 4
#>    Year Quarter ave_viewer Quarter_Label
#>   <dbl>   <int>      <dbl> <chr>
#> 1  2011       3       14.5 2011Q3
#> 2  2011       4       14.7 2011Q4
#> 3  2012       1       15.7 2012Q1
#> 4  2012       2       13.3 2012Q2
```

```r
# 设置中文显示
Sys.setlocale("LC_ALL", "Chinese")
```

```
#> [1] "LC_COLLATE=Chinese_China.936;LC_CTYPE=Chinese_China.936;LC_MONETARY=Chinese_China.936;LC_N
```

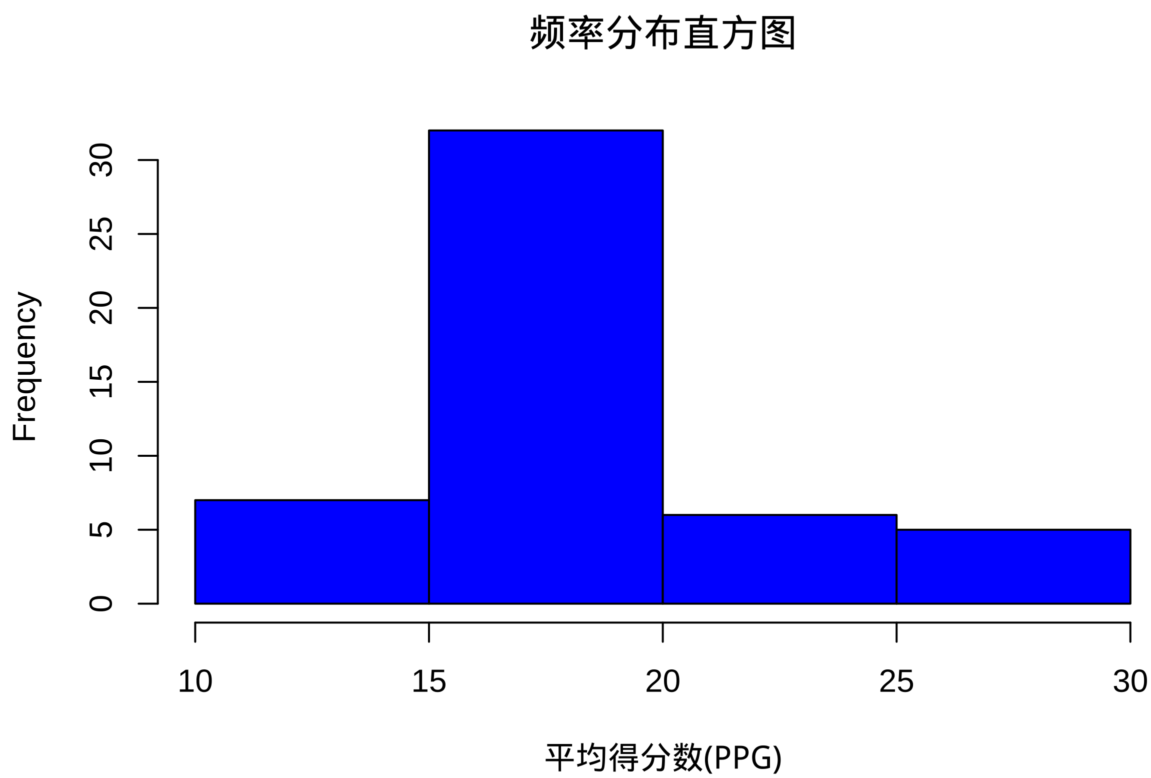
```
# 使用 ggplot2 绘制图表
ggplot(quarterly_data, aes(x = Quarter_Label, y = ave_viewer, group = 1)) +
    geom_line(color = "red") +
    labs(title = "2011 年至 2012 年期间季度平均收视率的折线图",
         x = " 季度",
         y = " 平均收视率") +
    theme(axis.text.x = element_text(angle = 45, hjust = 1, size = 8),
          panel.grid.major = element_blank(),
          panel.grid.minor = element_blank(),
          panel.background = element_blank())
```



问题 2：：NBAPlayerPts. (Attached Data: NBAPlayerPts)

```
# 加载文件
nba_score <- read.csv("data/NBAPlayerPts.csv")
# 问题 2.1
```

```r
# a. 显示频率分布
hist(nba_score$PPG, breaks = seq(10, 30, by = 5), xlab = '平均得分数 (PPG)', main = '频率分布直方图'
```




```r
# 查看并打印结果
hist_df <- hist(nba_score$PPG, breaks = seq(10, 30, by = 5),
                plot = FALSE)$counts
print('频率分布')
```

```
#> [1] "频率分布"
```

```r
print(hist_df)
```

```
#> [1]  7 32  6  5
```

```r
# b. 显示相对频率分布
hist_freq <- hist(nba_score$PPG, breaks = seq(10, 30, by = 5),
                  plot = FALSE)
```

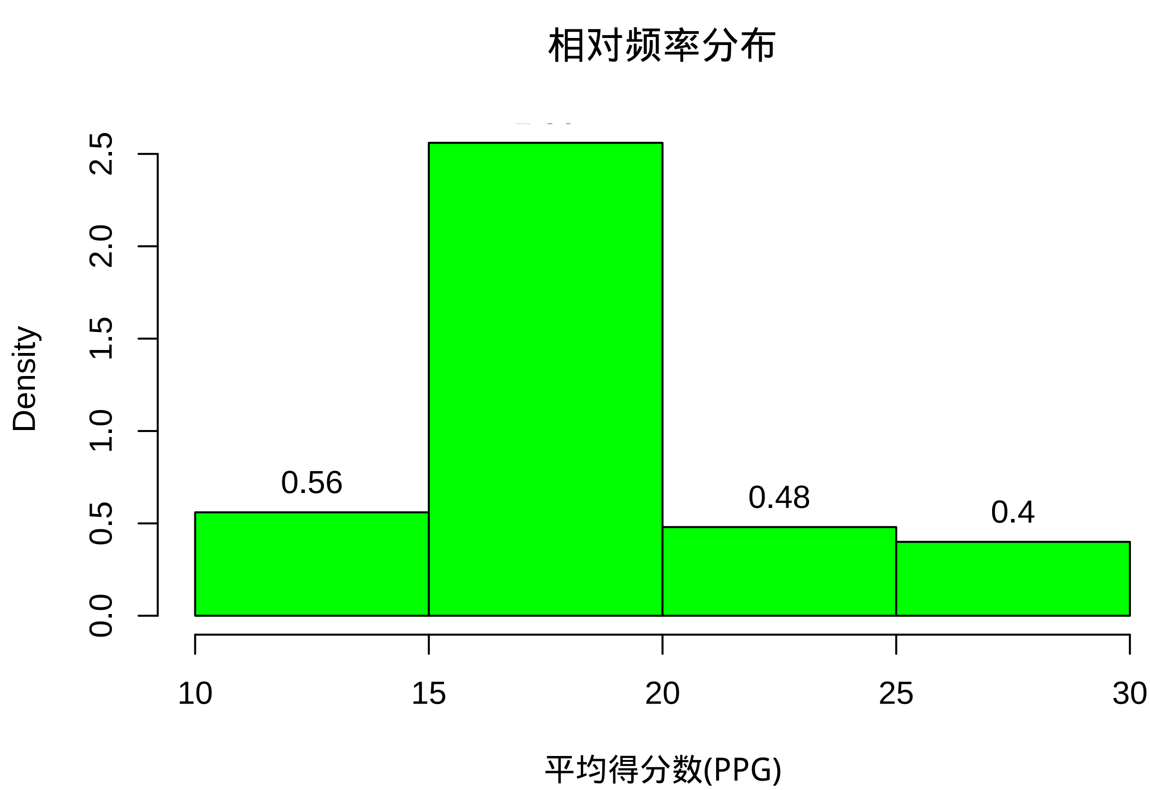
```
hist_freq$density <- hist_freq$counts / sum(hist_freq$counts) * 4

# 查看并打印结果
print('相对频率分布')
```

```
#> [1] "相对频率分布"
```

```
print(round(hist_freq$density, 2))
```

```
#> [1] 0.56 2.56 0.48 0.40
```

```
# 绘制相对频率分布直方图
plot(hist_freq, freq = FALSE, xlab = '平均得分数 (PPG)',
     main = '相对频率分布', col = 'green')

# 添加相对频率数据标签
text(hist_freq$mids, hist_freq$density, labels = round(hist_freq$density, 2),
     pos = 3)
```



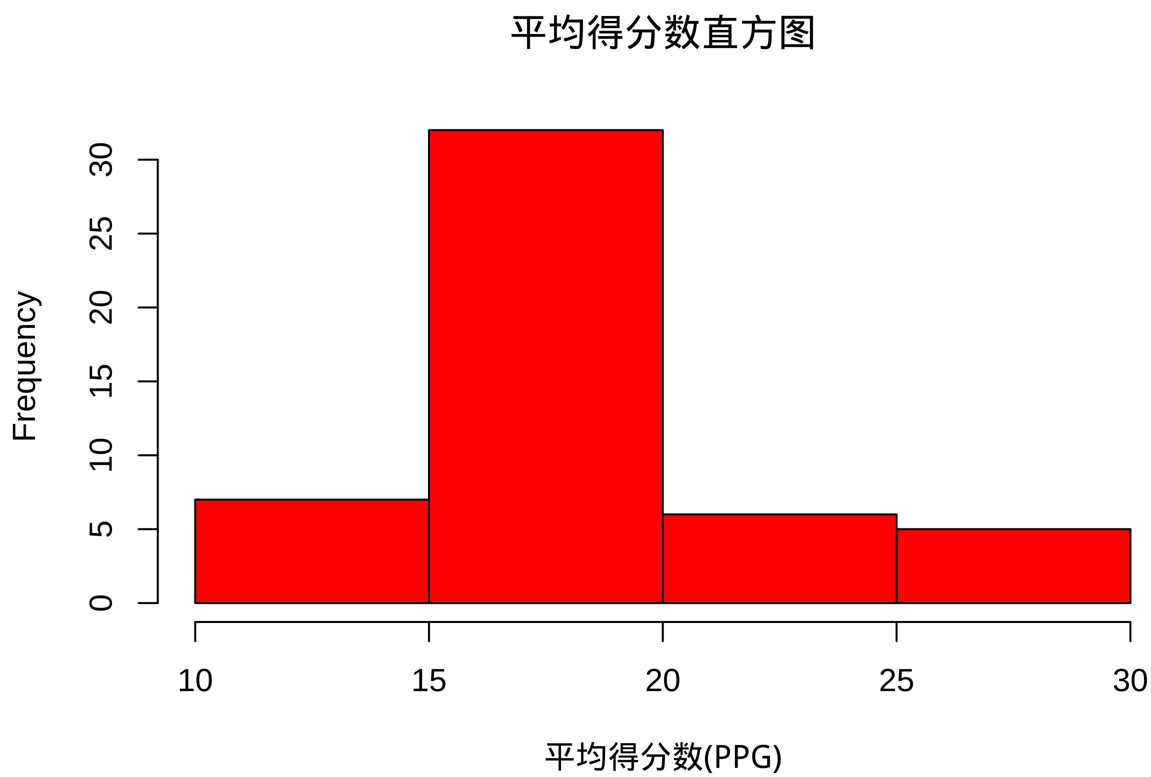
```r
# c. 显示累积百分比频率分布
hist_cum <- hist(nba_score$PPG, breaks = seq(10, 30, by = 5),
                 plot = FALSE)
hist_cum$counts <- hist_cum$counts / sum(hist_cum$counts)

# 求累计比例
hist_cum$accumulative_count <- cumsum(hist_cum$counts)

# 将小数转换为百分比并查看结果
print('累积百分比频率分布')
```

```
#> [1] "累积百分比频率分布"
```

```r
print(round(hist_cum$accumulative_count * 100, 2))
```

```
#> [1]  14  78  90 100
```

```r
# d. 展示平均得分数直方图
hist(nba_score$PPG, breaks = seq(10, 30, by = 5),
     xlab = '平均得分数 (PPG)', main = '平均得分数直方图', col = 'red')
```




```r
# e. 以直方图颜色深浅为判断依据，推测数据为右偏态分布，且 25-30 小组数据聚集

# f. 计算并打印平均得分至少 20 分的比例结果（频率保留两位小数）
pp_value <- length(nba_score$PPG[nba_score$PPG >= 20]) / length(nba_score$PPG)

# 查看并打印数据偏斜情况及比例结果
result_list <- list(
    " 数据偏斜情况" = " 右偏态分布",
    " 平均得分至少 20 分的比例" = round(pp_value, 2)
)
print(result_list)
```

```
#> $数据偏斜情况
#> [1] "右偏态分布"
#>
#> $平均得分至少20分的比例
#> [1] 0.22
```

问题 3: 一名研究人员报告调查结果，指出平均值的标准误差为 20。总体标准差为 500。

```
#a. 调查样本有多少
# 已知平均误差和标准差
simga <- 500
SE <- 20
# 根据公式计算样本 n
n <- (simga/SE)^2
# 输出样本 n
print(paste(" 样本量为: ",n))
```

```
#> [1] "样本量为:  625"
```

```
#b. 计算人口在 ±25 内的概率
# 转化成标准正态分布
standard <- simga/sqrt(n)
z_low <- (-25)/standard
z_upr <- 25/standard
# 使用 pnorm 函数计算数值
probability <- pnorm(z_upr)-pnorm(z_low)
# 结果百分比转换
probability_percentage <- round(probability*100,1)
# 输出结果
print(paste(" 人口在 ±25 内概率为:",probability_percentage,"%"))
```

```
#> [1] "人口在±25内概率为: 78.9 %"
```

问题 4：青年专业杂志

```
# 导入数据
professional <- read.csv('data/Professional.csv')
#1. Develop appropriate descriptive statistics to summarize the data.
summary(professional)
```

```
#>       Age            Gender          Real.Estate.Purchases Value.of.Investments
#>  Min.   :19.00   Length:410         Length:410            Min.   :     0
#>  1st Qu.:28.00   Class :character   Class :character      1st Qu.: 18300
#>  Median :30.00   Mode  :character   Mode  :character      Median : 24800
#>  Mean   :30.11                                            Mean   : 28538
```

```
#>  3rd Qu.:33.00                                         3rd Qu.: 34275
#>  Max.   :42.00                                         Max.   :133400
#>  Number.of.Transactions Broadband.Access   Household.Income Have.Children
#>  Min.   : 0.000         Length:410         Min.   : 16200   Length:410
#>  1st Qu.: 4.000         Class :character   1st Qu.: 51625   Class :character
#>  Median : 6.000         Mode  :character   Median : 66050   Mode  :character
#>  Mean   : 5.973                            Mean   : 74460
#>  3rd Qu.: 7.000                            3rd Qu.: 88775
#>  Max.   :21.000                            Max.   :322500
```

```
#2.Develop 95% confidence intervals for the mean age and household income of subscribers
# 计算年龄的平均值和置信区间
age_t <- t.test(professional$Age,conf.level = 0.95)$conf.int
# 结果保留两位小数
print(paste(" 年龄 95% 的置信区间为: [", round(age_t[1], 2), ", ", round(age_t[2], 2), "]"))
```

```
#> [1] "年龄95%的置信区间为: [ 29.72 ,  30.5 ]"
```

```
# 因原表格列名有 $ 符号，程序无法识别，现在进行名称替换
names <- names(professional)
names[7] <- "Household.Income"
colnames(professional) <- names
# 再计算家庭收入置信区间
income_t <- t.test(professional$Household.Income,conf.level = 0.95)$conf.int
print(paste(" 收入 95% 的置信区间为: [", round(income_t[1], 2), ", ", round(income_t[2], 2), "]"))
```

```
#> [1] "收入95%的置信区间为: [ 71079.26 ,  77839.77 ]"
```

```
#3.. Develop 95% confidence intervals for the proportion of subscribers who have broadband
# access at home and the proportion of subscribers who have children
# 总用户数
total_users <- 410

# 有宽带接入的用户数
broadband_users <- sum(grepl("Yes", professional$Broadband.Access))

# 有孩子的用户数
children_users <- sum(grepl("Yes", professional$Have.Children))
```

```
# 计算有宽带接入的用户比例的 95% 置信区间
ci_broadband <- prop.test(x = broadband_users, n = total_users)

# 计算有孩子的用户比例的 95% 置信区间
ci_children <- prop.test(x = children_users, n = total_users)

# 打印结果
cat("95% Confidence Interval for Broadband Access:\n")
```

```
#> 95% Confidence Interval for Broadband Access:
```

```
print(ci_broadband$conf.int)
```

```
#> [1] 0.5753252 0.6710862
#> attr(,"conf.level")
#> [1] 0.95
```

```
cat("\n95% Confidence Interval for Having Children:\n")
```

```
#>
#> 95% Confidence Interval for Having Children:
```

```
print(ci_children$conf.int)
```

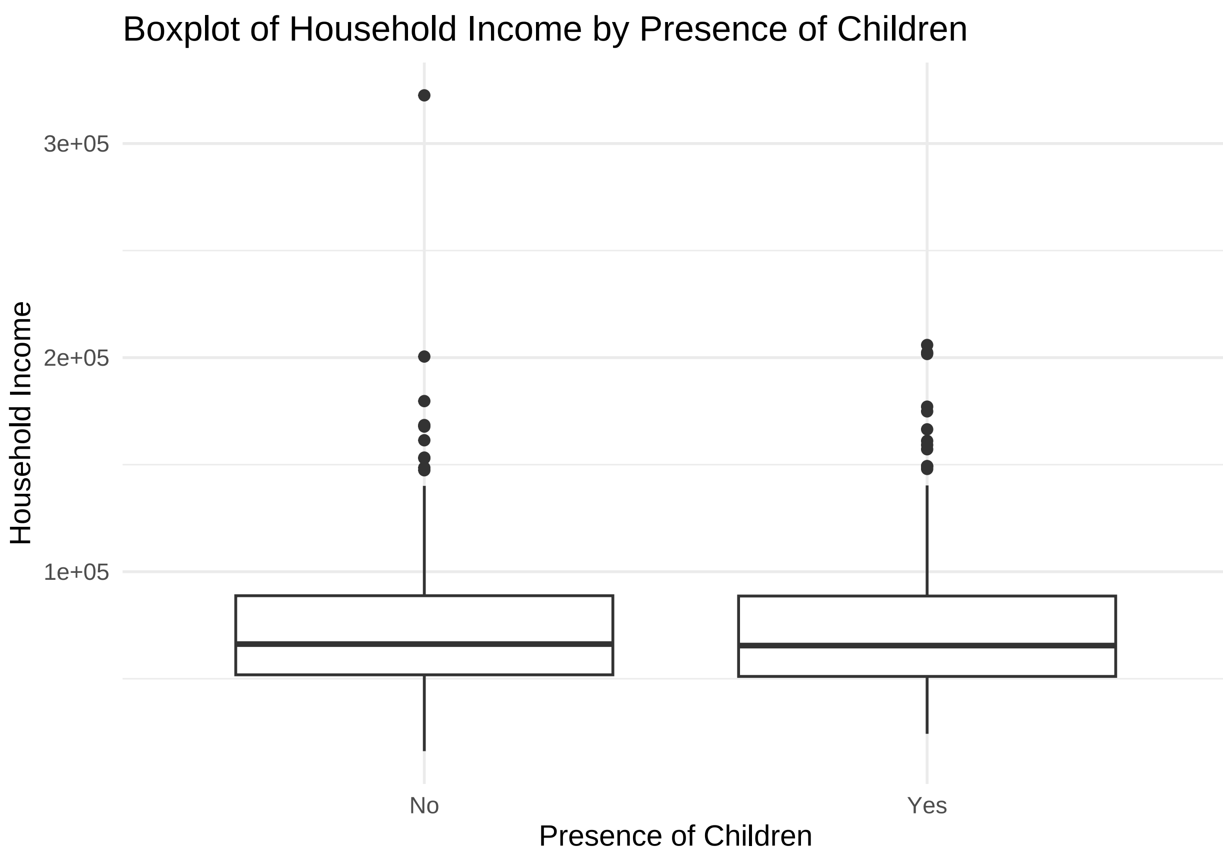
```
#> [1] 0.4845521 0.5830908
#> attr(,"conf.level")
#> [1] 0.95
```

```
#4. Would Young Professional be a good advertising outlet for online brokers? Justify your
#conclusion with statistical data.
# 加载必要的库
library(dplyr)

# 数据清洗-删除缺失值
professionals <- na.omit(professional)

# 定义年轻专业人士
young_professionals <- filter(professionals, Age < 35)
```

```r
# 描述性统计分析
summary_stats <- young_professionals %>%
  summarise(
    Average_Investments = mean(Value.of.Investments, na.rm = TRUE),
    Average_Transactions = mean(Number.of.Transactions, na.rm = TRUE),
    Household_Income = mean(Household.Income, na.rm = TRUE)
  )

# 相关性分析
correlation <- cor(young_professionals$Value.of.Investments, young_professionals$Number.of.Transac

# 回归分析
model <- lm(Number.of.Transactions ~ Value.of.Investments + Household.Income, data = young_profess

# 显示结果
summary(model)
```

```
#>
#> Call:
#> lm(formula = Number.of.Transactions ~ Value.of.Investments +
#>     Household.Income, data = young_professionals)
#>
#> Residuals:
#>    Min     1Q Median     3Q    Max
#> -6.236 -1.964 -0.408  1.230 14.057
#>
#> Coefficients:
#>                      Estimate Std. Error t value Pr(>|t|)
#> (Intercept)         5.218e+00  4.650e-01  11.221   <2e-16 ***
#> Value.of.Investments 1.521e-05  9.880e-06   1.539    0.125
#> Household.Income     3.938e-06  4.452e-06   0.885    0.377
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Residual standard error: 2.991 on 357 degrees of freedom
#> Multiple R-squared:  0.008684,   Adjusted R-squared:  0.00313
#> F-statistic: 1.564 on 2 and 357 DF,  p-value: 0.2108
```

```r
# 结论：截距项（Intercept）：估计值为 5.218e+00，对应的 t 值很大（11.221），且 p 值小于 2e-16，说明截距项
# 投资金额变量（Value.of.Investments）：估计值为 1.521e-05，t 值为 1.539，p 值为 0.125，说明在给定的显著
# 家庭收入变量（Household.Income）：估计值为 3.938e-06，t 值为 0.885，p 值为 0.377，同样表明该变量对交易
# 整体模型的拟合优度方面，多重 R 平方（Multiple R-squared）为 0.008684，调整后的 R 平方（Adjusted R-sq
#F 统计量为 1.564，对应的 p 值为 0.2108，进一步表明整个模型在统计上并不显著，即所选取的自变量（投资金额和

#5.Would this magazine be a good place to advertise for companies selling educational software and
# 加载 ggplot2 包
library(ggplot2)

# 确保数据框中的“是否有孩子”列是因子类型，以便于 ggplot 识别
professional$Have.Children <- as.factor(professional$Have.Children)

# 绘制箱线图，比较有孩子家庭和所有家庭的家庭收入
ggplot(professional, aes(x = Have.Children, y = Household.Income)) +
  geom_boxplot() +
  labs(title = "Boxplot of Household Income by Presence of Children",
       x = "Presence of Children",
       y = "Household Income") +
  theme_minimal()
```




```
# 结论：通过箱线图可以看出有孩子和没孩子家庭 House.income 水平差别不大。并不适合做儿童类广告。

#6. Comment on the types of articles you believe would be of interest to readers of Young
#Professional
```

问题 5:

```
#1.Conduct a hypothesis test for each sample at the .01 level of significance and determine what
#action, if any, should be taken. Provide the p-value for each test.
# 导入数据
quality_data <- read.csv("data/Quality.csv")
# 定义显著性水平
alpha <- 0.01

# 计算样本均值和标准差
sample_means <- apply(quality_data, 1, mean)
sample_sds <- apply(quality_data, 1, sd)
```

```r
# 总体标准差
sigma <- 0.21
n <- 30

# 进行假设检验
t_tests <- sapply(1:nrow(quality_data), function(i) {
  t_stat <- (sample_means[i] - 12) / (sigma / sqrt(n))
  p_value <- 2 * pt(abs(t_stat), df = n - 1, lower.tail = FALSE)
  list(t_stat = t_stat, p_value = p_value)
})

# 输出结果
t_tests
```

```
#>         [,1]         [,2]         [,3]          [,4]       [,5]      [,6]
#> t_stat  -5.868456    -8.541864    -7.107352     -1.956152  0.7824608 -5.607636
#> p_value 2.28638e-06  2.07292e-09  8.055516e-08  0.06014044 0.4402866 4.696334e-06
#>         [,7]          [,8]      [,9]        [,10]       [,11]       [,12]
#> t_stat  -4.368739     -2.477793 3.260253    -3.455869   3.651484    -1.564922
#> p_value 0.0001458471  0.0192882 0.002843649 0.001711572 0.001021295 0.1284495
#>         [,13]      [,14]      [,15]        [,16]      [,17]      [,18]
#> t_stat  2.347382   -0.4564355 4.49915      1.890947   -0.5216405 -5.738046
#> p_value 0.02594231 0.6514771  0.0001017738 0.06865983 0.6058821  3.275305e-06
#>         [,19]      [,20]       [,21]      [,22]      [,23]      [,24]
#> t_stat  2.673408   -3.129843   -0.1956152 2.412587   1.825742   8.867889
#> p_value 0.01220001 0.003967029 0.8462756  0.02239019 0.07820332 9.360888e-10
#>         [,25]     [,26]     [,27]      [,28]      [,29]        [,30]
#> t_stat  1.369306  0.9128709 1.956152   -2.412587  5.085995     3.586279
#> p_value 0.1814154 0.3688376 0.06014044 0.02239019 1.997275e-05 0.001214172
```

```r
#2 算每个样本的标准差
sample_sds
```

```
#>  [1] 0.22575798 0.27170756 0.23556669 0.18912077 0.11401754 0.19330460
#>  [7] 0.18191115 0.20566964 0.19908122 0.14930394 0.04082483 0.24589971
#> [13] 0.14719601 0.33129795 0.21515498 0.18839232 0.11401754 0.03366502
#> [19] 0.19050372 0.16268579 0.29136175 0.13524669 0.15165751 0.10614456
#> [25] 0.22156639 0.09678154 0.15286159 0.05057997 0.21763884 0.14453950
```

```
# 判断假设是否合理
mean(sample_sds)  # 计算样本标准差的平均值
```

```
#> [1] 0.1734486
```

```
#3
# 计算控制限
upper_limit <- 12 + 3 * (sigma / sqrt(n))
lower_limit <- 12 - 3 * (sigma / sqrt(n))

# 输出控制限
c(upper_limit, lower_limit)
```

```
#> [1] 12.11502 11.88498
```

```
#4.discuss the implications of changing the level of significance to a larger value. what mistake
#r error could increase if the level of significance is increased?
# 如果显著性水平增加，第一类错误（错误地拒绝正确的零假设）的风险会增加。
# 这意味着可能会更频繁地采取不必要的纠正措施，导致成本增加和生产效率降低。
```

问题 6：

```
# 导入数据
data <- read.csv("data/Occupancy.csv")
#1.Estimate the proportion of units rented during the first week of March 2007 and the first week
#of March 2008
# 将原始数据转化为 0/1，区分是否出租
data$Mar.07 <- ifelse(data$Mar.07=="Yes",1,0)
data$Mar.08 <- ifelse(data$Mar.08=="Yes",1,0)
# 计算样本大小
n <- nrow(data)
# 计算 2007 年 3 月第一周出租单位的比例
prop_2007 <- mean(data$Mar.07)  # 假设 CSV 文件中的列名是"March 2007"

# 计算 2008 年 3 月第一周出租单位的比例
prop_2008 <- mean(data$Mar.08)  # 假设 CSV 文件中的列名是"March 2008"

# 打印结果
cat("Proportion of units rented in Mar.07:", prop_2007, "\n")
```

```
#> Proportion of units rented in Mar.07: 0.35
```

```r
cat("Proportion of units rented in Mar.08:", prop_2008, "\n")
```

```
#> Proportion of units rented in Mar.08: 0.35
```

```r
#2.Provide a 95% confidence interval for the difference in proportions.
# 计算比例差异的标准误差
se_diff <- sqrt((prop_2007 * (1 - prop_2007) / n) + (prop_2008 * (1 - prop_2008) / n))

# 计算 95% 置信区间
ci_diff <- c(prop_2008 - prop_2007 - 1.96 * se_diff, prop_2008 - prop_2007 + 1.96 * se_diff)

# 打印结果
cat("95% Confidence Interval for the difference in proportions:", ci_diff, "\n")
```

```
#> 95% Confidence Interval for the difference in proportions: -0.09348604 0.09348604
```

```r
#3.. On the basis of your findings, does it appear March rental rates for 2008 will be up
#from those a year earlier?
# 判断置信区间是否完全大于 0
if (ci_diff[1] > 0) {
  cat(" 表明 08 年 3 月租金会同比上升.\n")
} else {
  cat(" 没有明显证据证明 08 年 3 月租金会同比上升.\n")
}
```

```
#> 没有明显证据证明08年3月租金会同比上升.
```

问题 7:Question #7: Air Force Training Program

```r
# 导入数据
train <- read.csv("data/Training.csv")

#1.. use appropriate descriptive statistics to summarize the training time data for each method.
#what similarities or differences do you observe from the sample data?
# 描述性统计
summary_current <- summary(train$Current)
summary_proposed <- summary(train$Proposed)
```

```
# 打印结果
cat(" 当前方法的描述性统计:\n")
```

```
#> 当前方法的描述性统计:
```

```
print(summary_current)
```

```
#>    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
#>   65.00   72.00   76.00   75.07   78.00   84.00
```

```
cat(" 提议方法的描述性统计:\n")
```

```
#> 提议方法的描述性统计:
```

```
print(summary_proposed)
```

```
#>    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
#>   69.00   74.00   76.00   75.43   77.00   82.00
```

```
#2.Comment on any difference between the population means for the two methods. Discuss
# your findings.
# t 检验
t_test_result <- t.test(train$Current, train$Proposed, var.equal = TRUE)
print(t_test_result)
```

```
#>
#>  Two Sample t-test
#>
#> data:  train$Current and train$Proposed
#> t = -0.60268, df = 120, p-value = 0.5479
#> alternative hypothesis: true difference in means is not equal to 0
#> 95 percent confidence interval:
#>  -1.5454793  0.8241679
#> sample estimates:
#> mean of x mean of y
#>  75.06557  75.42623
```

```
#3.c. compute the standard deviation and variance for each training method. conduct a hypothesis
#test about the equality of population variances for the two training methods. Discuss your
#findings
# 计算标准差和方差
sd_current <- sd(train$Current)
var_current <- var(train$Current)
sd_proposed <- sd(train$Proposed)
var_proposed <- var(train$Proposed)

# 方差齐性检验
var_test_result <- var.test(train$Current, train$Proposed)
print(var_test_result)
```

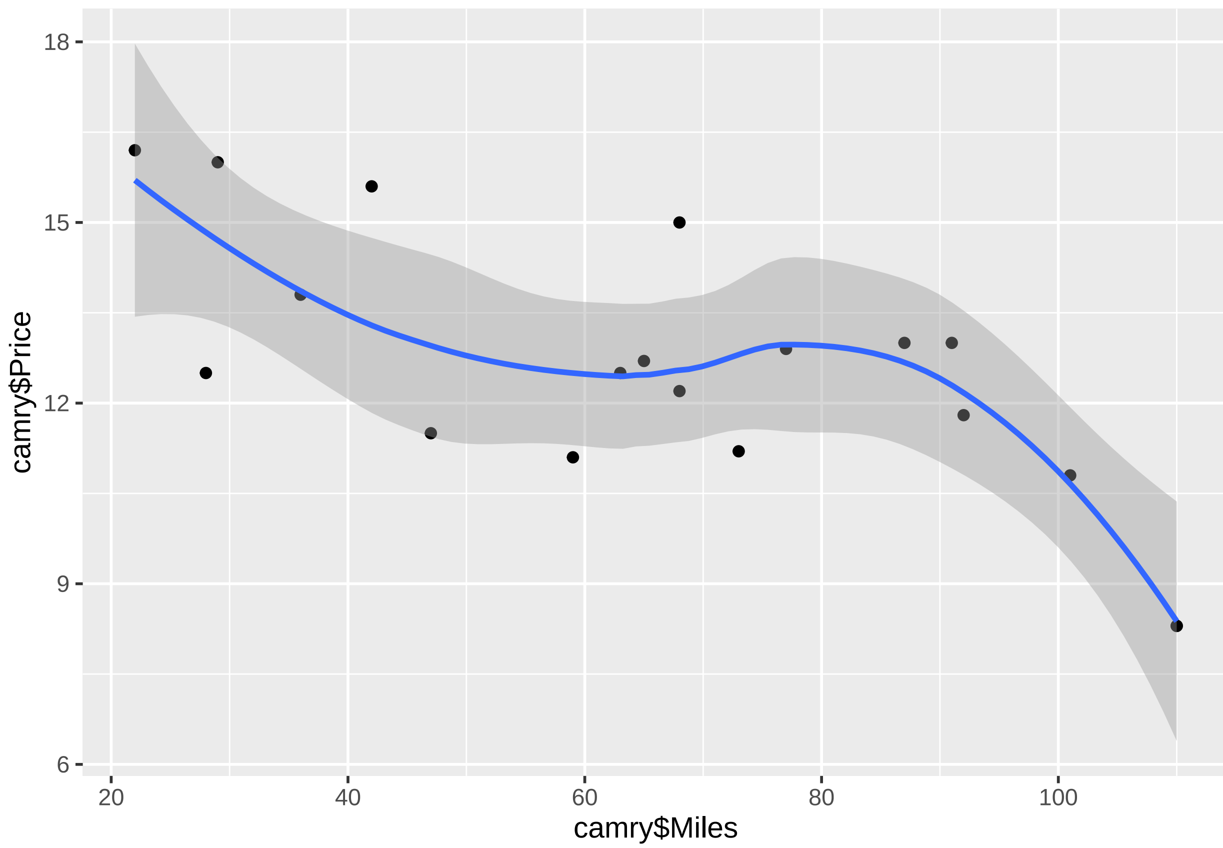
```
#>
#>  F test to compare two variances
#>
#> data:  train$Current and train$Proposed
#> F = 2.4773, num df = 60, denom df = 60, p-value = 0.000578
#> alternative hypothesis: true ratio of variances is not equal to 1
#> 95 percent confidence interval:
#>  1.486267 4.129135
#> sample estimates:
#> ratio of variances
#>           2.477296
```

```
#4. what conclusion can you reach about any differences between the two methods? what is your
#recommendation? explain
# 结论：两种方法的均值没有显著差异，但方差存在显著差异，表明提议方法在训练时间上更加一致。
#5.can you suggest other data or testing that might be desirable before making a final decision
#on the training program to be used in the future?
# 鉴于两种方法的均值相似，但提议方法的方差较小，可能更值得考虑采用提议方法，因为它可能提供更一致的训练体验
```

问题 8:The Toyota Camry is one of the best-selling cars in North America.

```
# 加载数据
camry <- read.csv("data/Camry.csv")
#1.a. Develop a scatter diagram with the car mileage on the horizontal axis and the price on the
#vertical axis.
# 1.a. 绘制散点图
```

```
ggplot(camry, aes(x = camry$Miles, y = camry$Price)) +
  geom_point() +  # 添加散点图
  geom_smooth()  # 添加默认的平滑拟合线
```




```
#2.b. what does the scatter diagram developed in part (a) indicate about the relationship between
#the two variables?
# 答：从散点图中，我们可以看出里程和价格之间存在负相关关系。随着里程的增加，价格呈下降趋势

#3.c. Develop the estimated regression equation that could be used to predict the price ($1000s)
#given the miles (1000s).
# 3.c. 估计回归方程
model <- lm(camry$Price ~ camry$Miles, data=camry)
summary(model)
```

```
#>
#> Call:
#> lm(formula = camry$Price ~ camry$Miles, data = camry)
#>
```

```
#> Residuals:
#>      Min       1Q   Median       3Q      Max 
#> -2.32408 -1.34194  0.05055  1.12898  2.52687 
#> 
#> Coefficients:
#>             Estimate Std. Error t value Pr(>|t|)    
#> (Intercept) 16.46976    0.94876  17.359 2.99e-12 ***
#> camry$Miles -0.05877    0.01319  -4.455 0.000348 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#> 
#> Residual standard error: 1.541 on 17 degrees of freedom
#> Multiple R-squared:  0.5387, Adjusted R-squared:  0.5115 
#> F-statistic: 19.85 on 1 and 17 DF,  p-value: 0.0003475
```

```r
#4.d. Test for a significant relationship at the .05 level of significance.
# 答：从回归方程的估计结果中，我们可以看到 Miles 的 p 值为 0.000348，远小于 0.05，因此在 0.05 的显著性水
#Miles 对 Price 有显著的影响。

#5.e. Did the estimated regression equation provide a good fit? Explain.
# 答：R 平方值 0.5387，调整后的 R 平方值为 0.5115，这表明回归方程对数据的拟合度较好，可以解释 51.15% 的

#6.f. Provide an interpretation for the slope of the estimated regression equation.
# 答：斜率-0.05877 表示每增加 1000 英里的里程，价格平均下降 0.05877 千美元。

#7.g. Suppose that you are considering purchasing a previously owned 2007 Camry that has been
#driven 60,000 miles. Using the estimated regression equation developed in part (c), predict the
#price for this car. Is this the price you would offer the seller

# 获取模型的系数
coefficients <- coef(model)
intercept <- coefficients[1]
slope <- coefficients[2]

# 计算预测价格
predicted_price <- intercept + slope * 60
predicted_price
```

```
#> (Intercept)
```

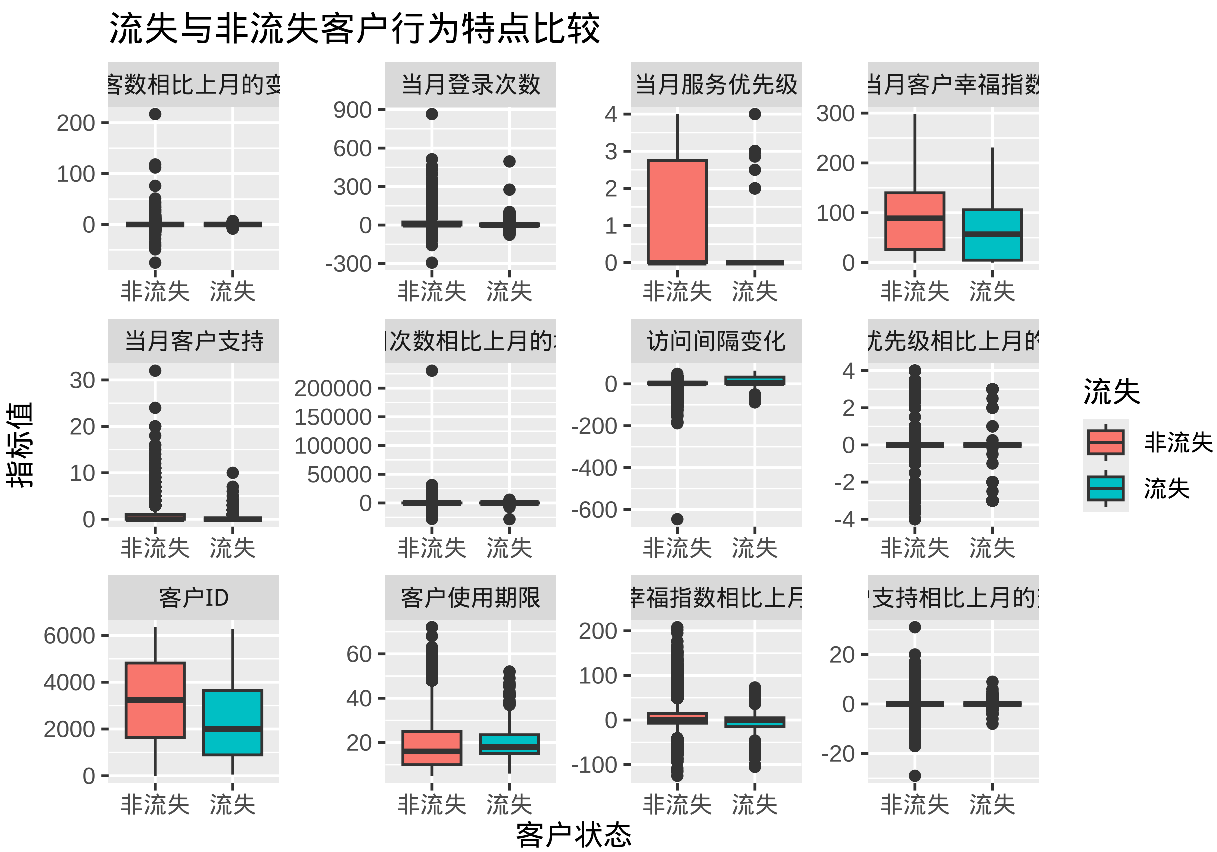
```
#>    12.94332
```

```
predicted_price_2 <- round(predicted_price, 2)
paste(" 预测价格 $",predicted_price_2," 千元")
```

```
#> [1] "预测价格$ 12.94 千元"
```

问题 9：附件 WE.xlsx 是某提供　站服务的 Internet 服务商的客户数据。数据包含了 6347 名客 # 户在 11 个指标上的表现。其中”流失“指标中 0 表示流失，”1“表示不流失，其他指标含义看变量命 # 名

```
#0. 导入数据
library(readxl)
data <- read_excel("data/WE.xlsx")
#1a. 通过可视化探索流失客户与□流失客户的□为特点（或特点对□），你能发现流失与□流失客
  # 户□为在哪些指标有可能存在显著不同？
data_long <- data %>%
  pivot_longer(cols = -流失, names_to = " 指标", values_to = " 值") %>%
  mutate(流失 = factor(流失, labels = c(" 非流失", " 流失")))

ggplot(data_long, aes(x = 流失, y = 值, fill = 流失)) +
  geom_boxplot() +
  facet_wrap(~指标, scales = "free") +
  labs(title = " 流失与非流失客户行为特点比较", x = " 客户状态", y = " 指标值")
```




```
#2b. 通过均值□较的□式验证上述不同是否显著。
# 计算均值并进行 t 检验
t_tests <- data %>%
  pivot_longer(cols = -流失, names_to = " 指标", values_to = " 值") %>%
  group_by(指标) %>%
  do({
    t_test <- t.test(.$值 [.$流失 == 0], .$值 [.$流失 == 1])
    data.frame(指标 = unique(.$指标), 非流失_mean = mean(.$值 [.$流失 == 0], na.rm = TRUE), 流失_mea
  }) %>%
  ungroup()

# 显示 t 检验结果
t_tests
```

```
#> # A tibble: 12 x 4
#>    指标                       非流失_mean 流失_mean  p_value
#>    <chr>                            <dbl>     <dbl>    <dbl>
#>  1 博客数相比上月的变化             0.171    -0.102  1.16e- 2
```

```
#>  2 客户ID                    3219.      2330.      5.98e-20
#>  3 客户使用期限                18.8       20.4      3.06e- 3
#>  4 客户幸福指数相比上月变化      5.53      -3.74     1.57e- 8
#>  5 客户支持相比上月的变化       -0.00930    0.0372  5.28e- 1
#>  6 当月客户幸福指数             88.6       63.3      2.10e-13
#>  7 当月客户支持                 0.724      0.372    6.28e- 8
#>  8 当月服务优先级               0.830      0.500    4.38e- 7
#>  9 当月登录次数                16.1        8.06     4.04e- 4
#> 10 服务优先级相比上月的变化      0.0327    -0.0167  5.22e- 1
#> 11 访问次数相比上月的增加       107.       -95.8     5.63e- 2
#> 12 访问间隔变化                 3.51       8.49     5.22e- 5
```

```r
print(t_tests)
```

```
#> # A tibble: 12 x 4
#>    指标                      非流失_mean 流失_mean  p_value
#>    <chr>                          <dbl>     <dbl>    <dbl>
#>  1 博客数相比上月的变化           0.171     -0.102  1.16e- 2
#>  2 客户ID                      3219.      2330.      5.98e-20
#>  3 客户使用期限                  18.8       20.4    3.06e- 3
#>  4 客户幸福指数相比上月变化        5.53      -3.74   1.57e- 8
#>  5 客户支持相比上月的变化         -0.00930    0.0372 5.28e- 1
#>  6 当月客户幸福指数               88.6       63.3    2.10e-13
#>  7 当月客户支持                   0.724      0.372  6.28e- 8
#>  8 当月服务优先级                 0.830      0.500  4.38e- 7
#>  9 当月登录次数                  16.1        8.06   4.04e- 4
#> 10 服务优先级相比上月的变化        0.0327    -0.0167 5.22e- 1
#> 11 访问次数相比上月的增加         107.       -95.8   5.63e- 2
#> 12 访问间隔变化                   3.51       8.49   5.22e- 5
```

```r
#3.c. 以”流失“为因变量，其他你认为重要的变量为□变量（提示：a、b 两步的发现），建□回归□
  # 程对是否流失进□预测。
model <- glm(流失 ~ 客户 ID + 当月客户幸福指数 + 客户幸福指数相比上月变化 + 当月客户支持  + 当月服务优先

# 显示模型摘要
summary(model)
```

```
#> 
#> Call:
```

```
#> glm(formula = 流失 ~ 客户ID + 当月客户幸福指数 + 客户幸福指数相比上月变化 +
#>     当月客户支持 + 当月服务优先级, family = binomial, data = data)
#>
#> Coefficients:
#>                            Estimate Std. Error z value Pr(>|z|)
#> (Intercept)               -1.211e+00  1.359e-01  -8.912   <2e-16 ***
#> 客户ID                    -3.539e-04  3.366e-05 -10.516   <2e-16 ***
#> 当月客户幸福指数          -9.305e-03  1.125e-03  -8.267   <2e-16 ***
#> 客户幸福指数相比上月变化 -4.194e-03  2.285e-03  -1.835   0.0665 .
#> 当月客户支持               6.730e-03  6.822e-02   0.099   0.9214
#> 当月服务优先级            -3.799e-02  7.307e-02  -0.520   0.6031
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> (Dispersion parameter for binomial family taken to be 1)
#>
#>     Null deviance: 2553.1  on 6346  degrees of freedom
#> Residual deviance: 2371.3  on 6341  degrees of freedom
#> AIC: 2383.3
#>
#> Number of Fisher Scoring iterations: 6
```

```
#4.d. 根据上□步预测的结果，对尚未流失（流失 =0）的客户进□流失可能性排序，并给出流失可能
  # 性最□的前 100 名□户 ID 列表。
# 筛选出尚未流失的客户
data_non_churn <- data[data$流失 == 0, ]

# 预测尚未流失的客户流失可能性
predictions <- predict(model, newdata = data_non_churn, type = "response")

# 将预测结果添加到筛选后的数据框中
data_non_churn$predictions <- predictions

# 对尚未流失的客户进行排序
data_non_churn_sorted <- data_non_churn[order(-data_non_churn$predictions), ]

# 显示流失可能性最大的前 100 名用户 ID
top100_users <- head(data_non_churn_sorted$客户 ID, 100)
print(top100_users)
```

```
#>   [1]  109   76   57  318  305  240  183    1  271    3   14   18   21  110   59
#>  [16]   51  703  123  101  104  106  228  119  121  146  425   55  137  154  165
#>  [31]  415  171  407  190  246  212  142  244  254   68  272  278  279   95   61
#>  [46]  572  346 1141  641  374  376  704  400   75  413  416 1181  423  427   89
#>  [61]  440  798  444   69   64  475  839  488  622  526  508  882  203  551  207
#>  [76]  570  583   62  777  846  604 1574  623  625  141 1971  128  210  645  651
#>  [91]  563  678  689  302   42  585  871 1520  350 1010
```