chap8.R

spoor

Sun Mar 26 05:55:04 2017

```
# Predictive Model for Los Angeles Dodgers Promotion and Attendance (R)

library(car)  # special functions for linear regression
```

```
## Warning: package 'car' was built under R version 3.2.5
```

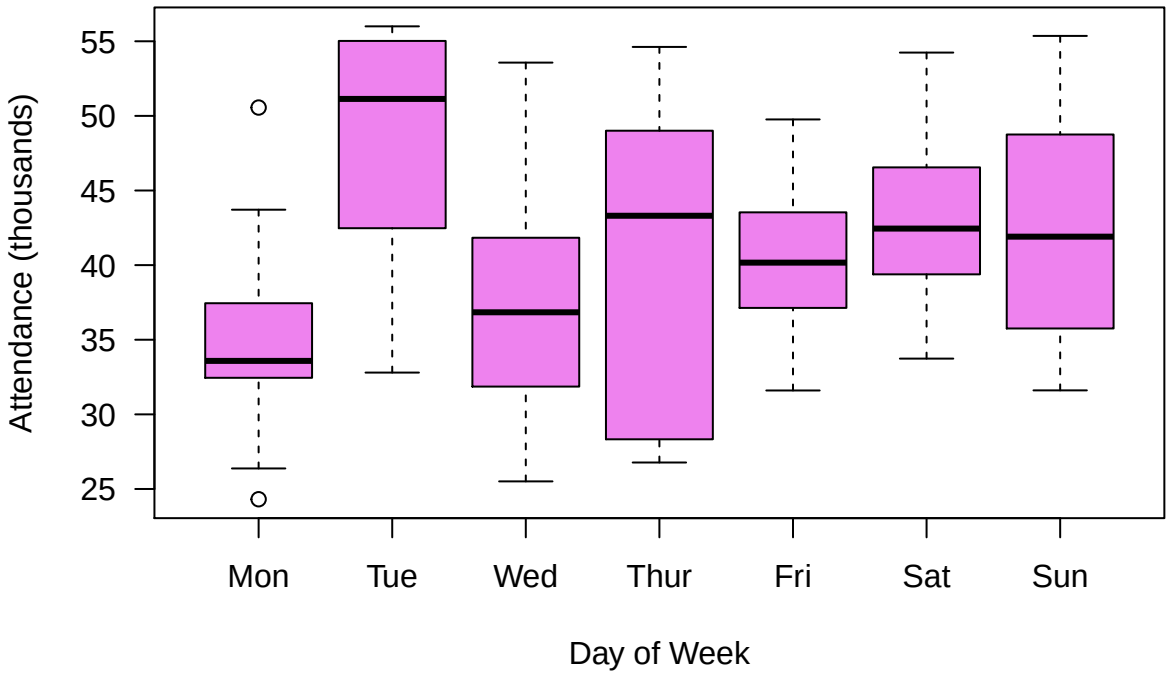
```
library(lattice)  # graphics package
```

```
## Warning: package 'lattice' was built under R version 3.2.5
```

```
# read in data and create a data frame called dodgers
dodgers <- read.csv("C:/Users/spoor/Desktop/Marketing Analytics/dodgers.csv")
print(str(dodgers))  # check the structure of the data frame
```

```
## 'data.frame':    81 obs. of  12 variables:
##  $ month      : Factor w/ 7 levels "APR","AUG","JUL",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ day        : int  10 11 12 13 14 15 23 24 25 27 ...
##  $ attend     : int  56000 29729 28328 31601 46549 38359 26376 44014 26345 44807 ...
##  $ day_of_week: Factor w/ 7 levels "Friday","Monday",..: 6 7 5 1 3 4 2 6 7 1 ...
##  $ opponent   : Factor w/ 17 levels "Angels","Astros",..: 13 13 13 11 11 11 3 3 3 10 ...
##  $ temp       : int  67 58 57 54 57 65 60 63 64 66 ...
##  $ skies      : Factor w/ 2 levels "Clear ","Cloudy": 1 2 2 2 2 1 2 2 2 1 ...
##  $ day_night  : Factor w/ 2 levels "Day","Night": 1 2 2 2 2 1 2 2 2 2 ...
##  $ cap        : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 1 1 1 1 ...
##  $ shirt      : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 1 1 1 1 ...
##  $ fireworks  : Factor w/ 2 levels "NO","YES": 1 1 1 2 1 1 1 1 1 2 ...
##  $ bobblehead : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 1 1 1 1 ...
## NULL
```

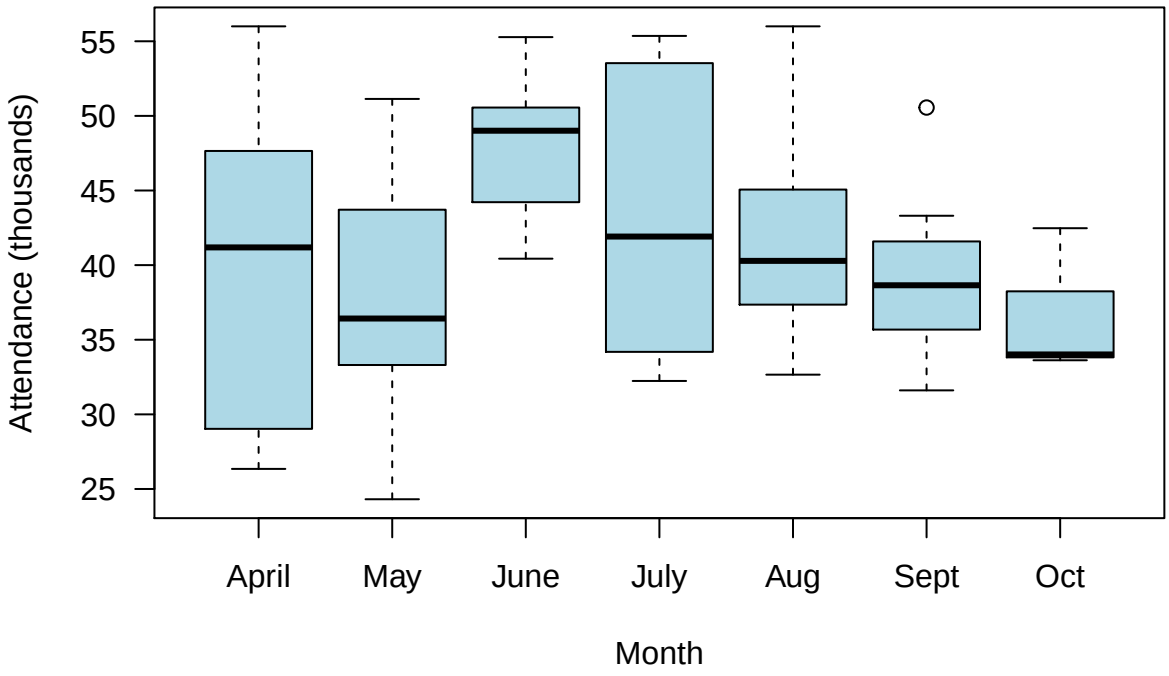
```
# define an ordered day-of-week variable
# for plots and data summaries
dodgers$ordered_day_of_week <- with(data=dodgers,
  ifelse ((day_of_week == "Monday"),1,
  ifelse ((day_of_week == "Tuesday"),2,
  ifelse ((day_of_week == "Wednesday"),3,
  ifelse ((day_of_week == "Thursday"),4,
  ifelse ((day_of_week == "Friday"),5,
  ifelse ((day_of_week == "Saturday"),6,7)))))))
dodgers$ordered_day_of_week <- factor(dodgers$ordered_day_of_week, levels=1:7,
labels=c("Mon", "Tue", "Wed", "Thur", "Fri", "Sat", "Sun"))

# exploratory data analysis with standard graphics: attendance by day of week
with(data=dodgers,plot(ordered_day_of_week, attend/1000,
xlab = "Day of Week", ylab = "Attendance (thousands)",
col = "violet", las = 1))
```



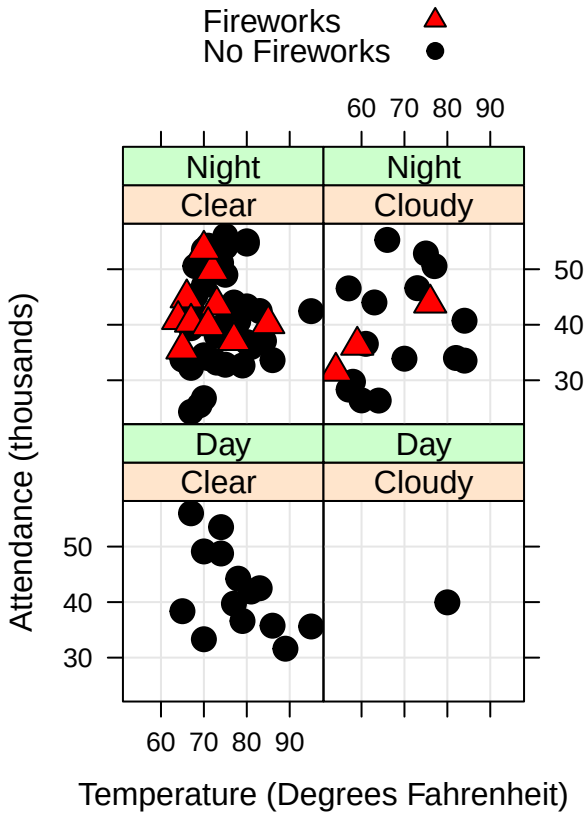

```
# when do the Dodgers use bobblehead promotions
with(dodgers, table(bobblehead,ordered_day_of_week)) # bobbleheads on Tuesday
```

```
##           ordered_day_of_week
## bobblehead Mon Tue Wed Thur Fri Sat Sun
##        NO   12   7  12    3  13  11  12
##        YES   0   6   0    2   0   2   1
```

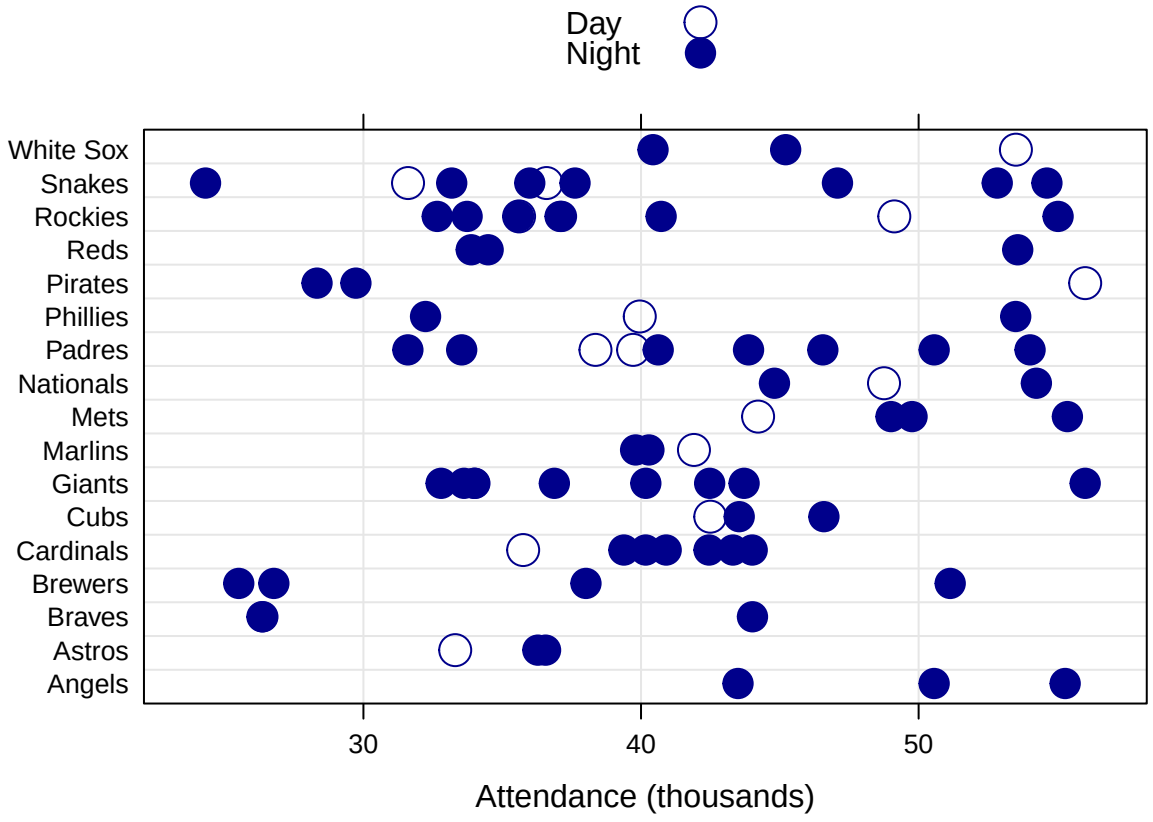
```
# define an ordered month variable
# for plots and data summaries
dodgers$ordered_month <- with(data=dodgers,
  ifelse ((month == "APR"),4,
  ifelse ((month == "MAY"),5,
  ifelse ((month == "JUN"),6,
  ifelse ((month == "JUL"),7,
  ifelse ((month == "AUG"),8,
  ifelse ((month == "SEP"),9,10)))))))
dodgers$ordered_month <- factor(dodgers$ordered_month, levels=4:10,
labels = c("April", "May", "June", "July", "Aug", "Sept", "Oct"))

# exploratory data analysis with standard R graphics: attendance by month
with(data=dodgers,plot(ordered_month,attend/1000, xlab = "Month",
ylab = "Attendance (thousands)", col = "light blue", las = 1))
```




```
# exploratory data analysis displaying many variables
# looking at attendance and conditioning on day/night
# the skies and whether or not fireworks are displayed
library(lattice) # used for plotting
# let us prepare a graphical summary of the dodgers data
group.labels <- c("No Fireworks","Fireworks")
group.symbols <- c(21,24)
group.colors <- c("black","black")
group.fill <- c("black","red")
xyplot(attend/1000 ~temp| skies + day_night,
    data = dodgers, groups = fireworks, pch = group.symbols,
    aspect = 1, cex = 1.5, col = group.colors, fill = group.fill,
    layout = c(2, 2), type = c("p","g"),
    strip=strip.custom(strip.levels=TRUE,strip.names=FALSE, style=1),
    xlab = "Temperature (Degrees Fahrenheit)",
    ylab = "Attendance (thousands)",
    key = list(space = "top",
        text = list(rev(group.labels),col = rev(group.colors)),
        points = list(pch = rev(group.symbols), col = rev(group.colors),
        fill = rev(group.fill))))
```




```
# attendance by opponent and day/night game
group.labels <- c("Day","Night")
group.symbols <- c(1,20)
group.symbols.size <- c(2,2.75)
bwplot(opponent ~ attend/1000, data = dodgers, groups = day_night,
    xlab = "Attendance (thousands)",
    panel = function(x, y, groups, subscripts, ...)
       {panel.grid(h = (length(levels(dodgers$opponent)) - 1), v = -1)
        panel.stripplot(x, y, groups = groups, subscripts = subscripts,
        cex = group.symbols.size, pch = group.symbols, col = "darkblue")
       },
    key = list(space = "top",
    text = list(group.labels,col = "black"),
    points = list(pch = group.symbols, cex = group.symbols.size,
    col = "darkblue")))
```




```
# employ training-and-test regimen for model validation
set.seed(1234) # set seed for repeatability of training-and-test split
training_test <- c(rep(1,length=trunc((2/3)*nrow(dodgers))),
rep(2,length=(nrow(dodgers) - trunc((2/3)*nrow(dodgers)))))
dodgers$training_test <- sample(training_test) # random permutation
dodgers$training_test <- factor(dodgers$training_test,
  levels=c(1,2), labels=c("TRAIN","TEST"))
dodgers.train <- subset(dodgers, training_test == "TRAIN")
print(str(dodgers.train)) # check training data frame
```

```
## 'data.frame':    54 obs. of  15 variables:
##  $ month              : Factor w/ 7 levels "APR","AUG","JUL",..: 1 1 1 1 1 1 1 5 5 5 ...
##  $ day                : int  10 11 12 23 24 27 29 7 12 14 ...
##  $ attend             : int  56000 29729 28328 26376 44014 44807 48753 43713 33735 24312 ...
##  $ day_of_week        : Factor w/ 7 levels "Friday","Monday",..: 6 7 5 2 6 1 4 2 3 2 ...
##  $ opponent           : Factor w/ 17 levels "Angels","Astros",..: 13 13 13 3 3 10 10 7 15 16 ...
##  $ temp               : int  67 58 57 60 63 66 74 67 65 67 ...
##  $ skies              : Factor w/ 2 levels "Clear ","Cloudy": 1 2 2 2 2 1 1 1 1 1 ...
##  $ day_night          : Factor w/ 2 levels "Day","Night": 1 2 2 2 2 2 1 2 2 2 ...
##  $ cap                : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 1 1 1 1 ...
##  $ shirt              : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 2 1 1 1 ...
##  $ fireworks          : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 2 1 1 1 1 ...
##  $ bobblehead         : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 1 1 1 1 ...
##  $ ordered_day_of_week: Factor w/ 7 levels "Mon","Tue","Wed",..: 2 3 4 1 2 5 7 1 6 1 ...
##  $ ordered_month      : Factor w/ 7 levels "April","May",..: 1 1 1 1 1 1 1 2 2 2 ...
##  $ training_test      : Factor w/ 2 levels "TRAIN","TEST": 1 1 1 1 1 1 1 1 1 1 ...
```

```
## NULL
```

```
dodgers.test <- subset(dodgers, training_test == "TEST")
print(str(dodgers.test)) # check test data frame
```

```
## 'data.frame':    27 obs. of  15 variables:
##  $ month              : Factor w/ 7 levels "APR","AUG","JUL",..: 1 1 1 1 1 5 5 5 5 5 ...
##  $ day                : int  13 14 15 25 28 8 9 11 13 18 ...
##  $ attend             : int  31601 46549 38359 26345 54242 32799 33993 35591 49124 40906 ...
##  $ day_of_week        : Factor w/ 7 levels "Friday","Monday",..: 1 3 4 7 3 6 7 1 4 1 ...
##  $ opponent           : Factor w/ 17 levels "Angels","Astros",..: 11 11 11 3 10 7 7 15 15 5 ...
##  $ temp               : int  54 57 65 64 71 75 71 65 70 64 ...
##  $ skies              : Factor w/ 2 levels "Clear ","Cloudy": 2 2 1 2 1 1 1 1 1 1 ...
##  $ day_night          : Factor w/ 2 levels "Day","Night": 2 2 1 2 2 2 2 2 1 2 ...
##  $ cap                : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 1 1 1 1 ...
##  $ shirt              : Factor w/ 2 levels "NO","YES": 1 1 1 1 1 1 1 1 1 1 ...
##  $ fireworks          : Factor w/ 2 levels "NO","YES": 2 1 1 1 1 1 1 2 1 2 ...
##  $ bobblehead         : Factor w/ 2 levels "NO","YES": 1 1 1 1 2 1 1 1 1 1 ...
##  $ ordered_day_of_week: Factor w/ 7 levels "Mon","Tue","Wed",..: 5 6 7 3 6 2 3 5 7 5 ...
##  $ ordered_month      : Factor w/ 7 levels "April","May",..: 1 1 1 1 1 2 2 2 2 2 ...
##  $ training_test      : Factor w/ 2 levels "TRAIN","TEST": 2 2 2 2 2 2 2 2 2 2 ...
## NULL
```

```
# specify a simple model with bobblehead entered last
my.model <- {attend ~ ordered_month + ordered_day_of_week + bobblehead}

# fit the model to the training set
train.model.fit <- lm(my.model, data = dodgers.train)
# summary of model fit to the training set
print(summary(train.model.fit))
```

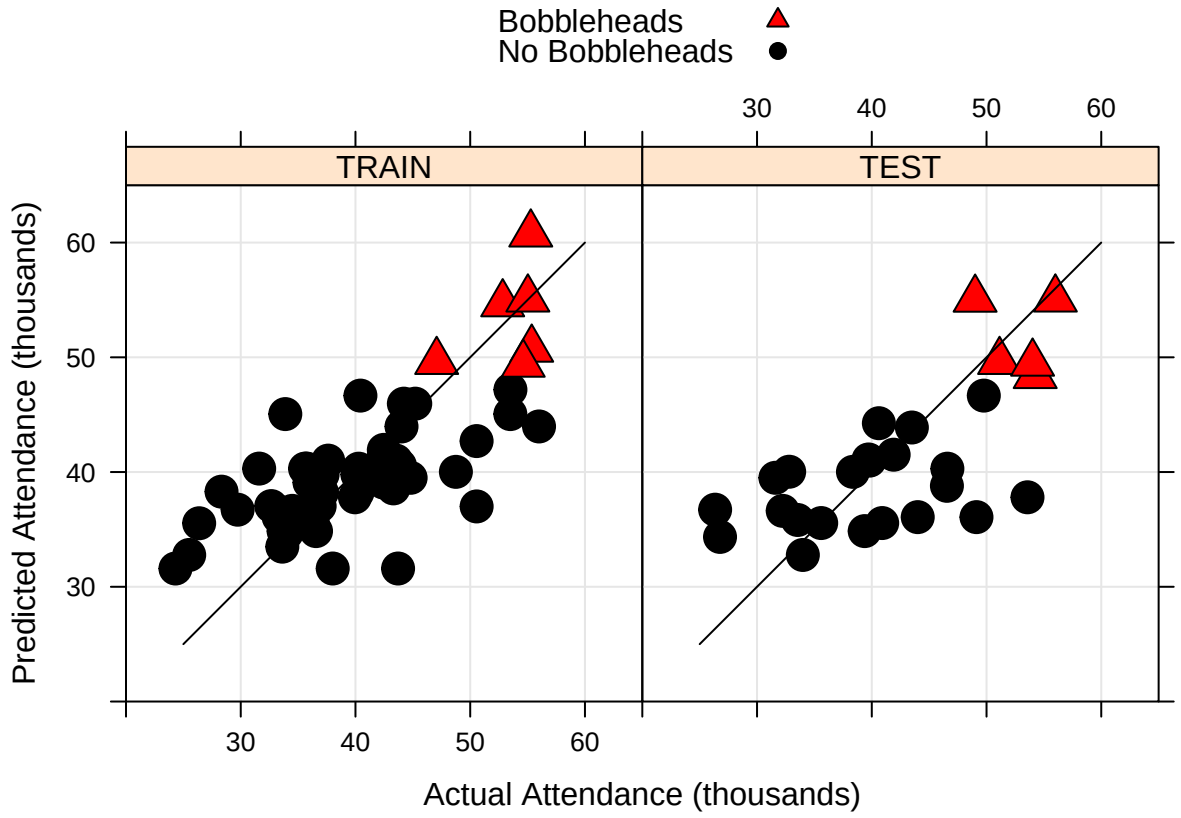
```
##
## Call:
## lm(formula = my.model, data = dodgers.train)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -11168.1  -3302.9   -101.9   3105.6  13556.2
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)               35537.0     3301.4  10.764 2.21e-13 ***
## ordered_monthMay          -3945.3     3507.2  -1.125   0.2673
## ordered_monthJune          7162.4     3876.3   1.848   0.0720 .
## ordered_monthJuly          1080.0     3524.6   0.306   0.7609
## ordered_monthAug           1496.0     3350.7   0.446   0.6577
## ordered_monthSept           284.9     3417.2   0.083   0.9340
## ordered_monthOct          -2039.0     4546.1  -0.449   0.6562
## ordered_day_of_weekTue     8435.1     3482.1   2.422   0.0200 *
## ordered_day_of_weekWed     1181.9     3125.2   0.378   0.7073
## ordered_day_of_weekThur    2753.8     4700.3   0.586   0.5612
## ordered_day_of_weekFri     3962.3     3164.0   1.252   0.2177
## ordered_day_of_weekSat     3261.3     3293.1   0.990   0.3280
## ordered_day_of_weekSun     4479.6     3284.5   1.364   0.1802
## bobbleheadYES              9604.5     3607.0   2.663   0.0111 *
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6423 on 40 degrees of freedom
## Multiple R-squared:  0.5402, Adjusted R-squared:  0.3907
## F-statistic: 3.614 on 13 and 40 DF,  p-value: 0.0008601
```

```
# training set predictions from the model fit to the training set
dodgers.train$predict_attend <- predict(train.model.fit)

# test set predictions from the model fit to the training set
dodgers.test$predict_attend <- predict(train.model.fit,
  newdata = dodgers.test)

# compute the proportion of response variance
# accounted for when predicting out-of-sample
cat("\n","Proportion of Test Set Variance Accounted for: ",
round((with(dodgers.test,cor(attend,predict_attend)^2)),
  digits=3),"\n",sep="")
```

```
##
## Proportion of Test Set Variance Accounted for: 0.453
```

```
# merge the training and test sets for plotting
dodgers.plotting.frame <- rbind(dodgers.train,dodgers.test)

# generate predictive modeling visual for management
group.labels <- c("No Bobbleheads","Bobbleheads")
group.symbols <- c(21,24)
group.colors <- c("black","black")
group.fill <- c("black","red")
xyplot(predict_attend/1000 ~ attend/1000 | training_test,
       data = dodgers.plotting.frame, groups = bobblehead, cex = 2,
       pch = group.symbols, col = group.colors, fill = group.fill,
       layout = c(2, 1), xlim = c(20,65), ylim = c(20,65),
       aspect=1, type = c("p","g"),
       panel=function(x,y, ...)
            {panel.xyplot(x,y,...)
             panel.segments(25,25,60,60,col="black",cex=2)
            },
       strip=function(...) strip.default(..., style=1),
       xlab = "Actual Attendance (thousands)",
       ylab = "Predicted Attendance (thousands)",
       key = list(space = "top",
              text = list(rev(group.labels),col = rev(group.colors)),
              points = list(pch = rev(group.symbols),
              col = rev(group.colors),
              fill = rev(group.fill))))
```




```
# use the full data set to obtain an estimate of the increase in
# attendance due to bobbleheads, controlling for other factors
my.model.fit <- lm(my.model, data = dodgers)  # use all available data
print(summary(my.model.fit))
```

```
##
## Call:
## lm(formula = my.model, data = dodgers)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10786.5  -3628.1   -516.1   2230.2  14351.0
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)              33909.16    2521.81  13.446  < 2e-16 ***
## ordered_monthMay         -2385.62    2291.22  -1.041  0.30152
## ordered_monthJune         7163.23    2732.72   2.621  0.01083 *
## ordered_monthJuly         2849.83    2578.60   1.105  0.27303
## ordered_monthAug          2377.92    2402.91   0.990  0.32593
## ordered_monthSept           29.03    2521.25   0.012  0.99085
## ordered_monthOct          -662.67    4046.45  -0.164  0.87041
## ordered_day_of_weekTue    7911.49    2702.21   2.928  0.00466 **
## ordered_day_of_weekWed    2460.02    2514.03   0.979  0.33134
## ordered_day_of_weekThur    775.36    3486.15   0.222  0.82467
## ordered_day_of_weekFri    4883.82    2504.65   1.950  0.05537 .
```

```
## ordered_day_of_weekSat   6372.06    2552.08   2.497  0.01500 *
## ordered_day_of_weekSun   6724.00    2506.72   2.682  0.00920 **
## bobbleheadYES           10714.90    2419.52   4.429 3.59e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6120 on 67 degrees of freedom
## Multiple R-squared:  0.5444, Adjusted R-squared:  0.456
## F-statistic: 6.158 on 13 and 67 DF,  p-value: 2.083e-07
```

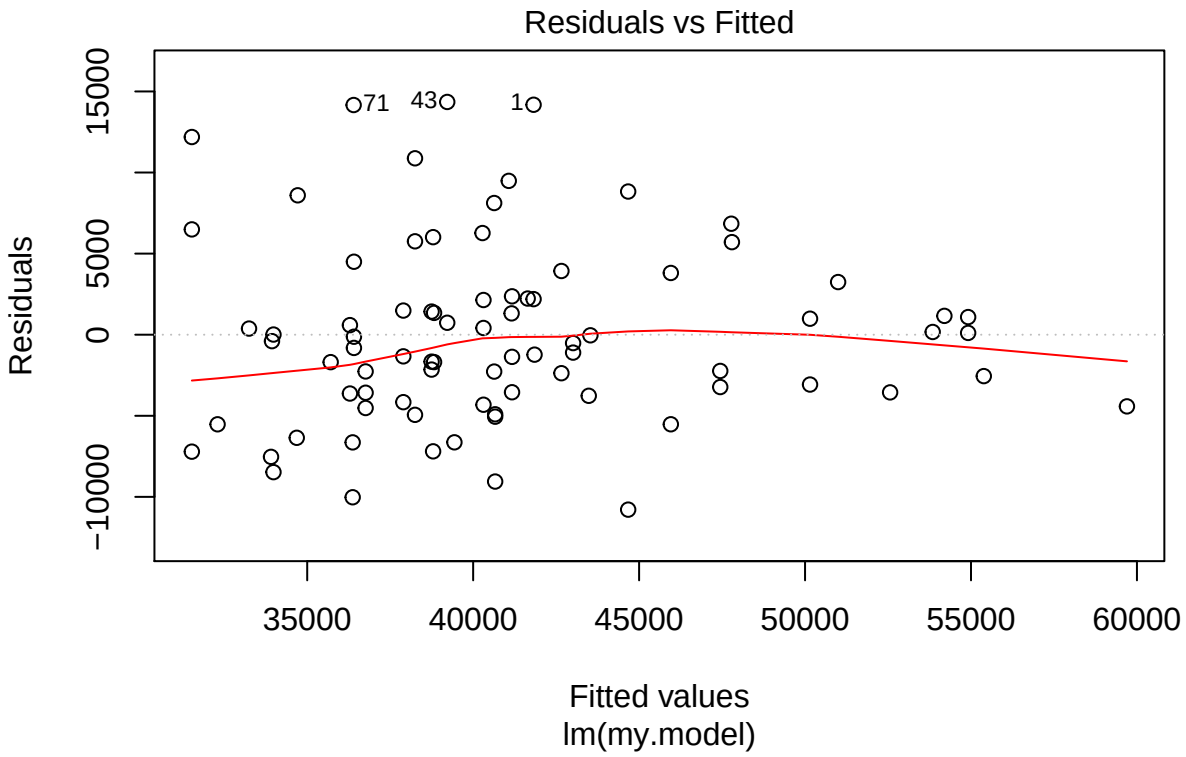
```
# tests statistical significance of the bobblehead promotion
# type I anova computes sums of squares for sequential tests
print(anova(my.model.fit))
```

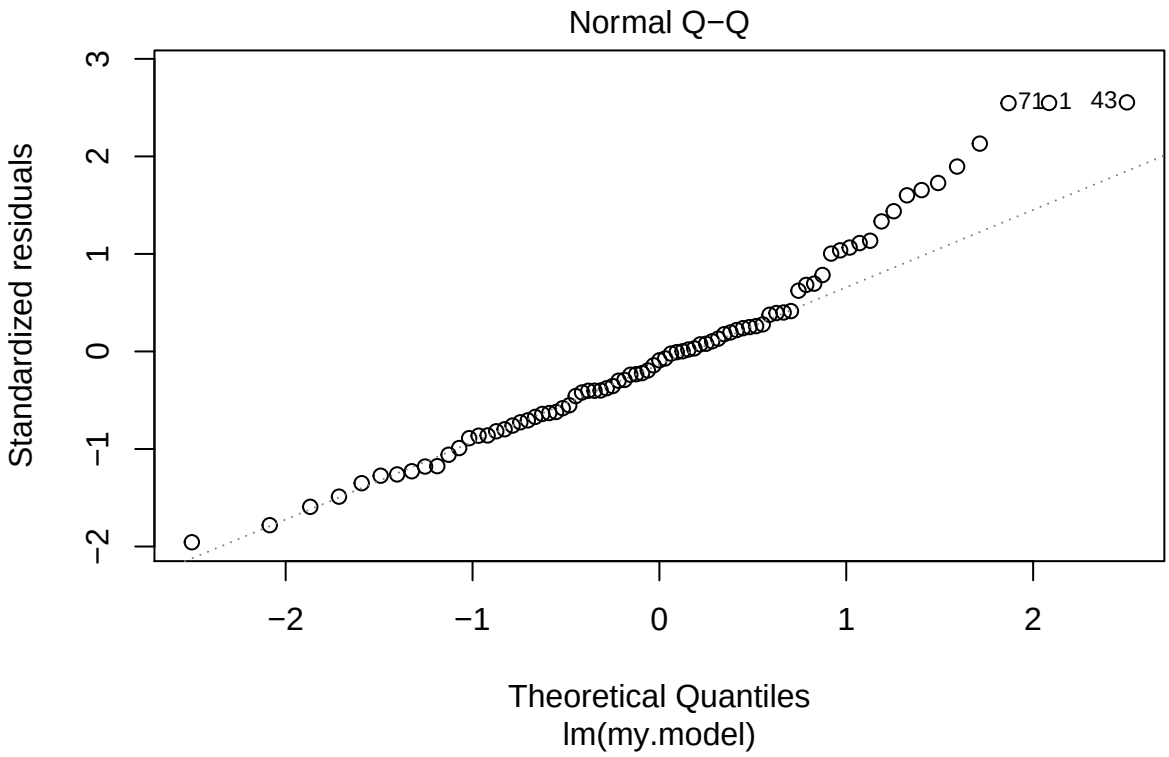
```
## Analysis of Variance Table
##
## Response: attend
##                      Df     Sum Sq   Mean Sq F value    Pr(>F)
## ordered_month         6  948958117 158159686  4.2225  0.001158 **
## ordered_day_of_week   6 1314813030 219135505  5.8504 6.002e-05 ***
## bobblehead            1  734587177 734587177 19.6118 3.590e-05 ***
## Residuals            67 2509574563  37456337
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

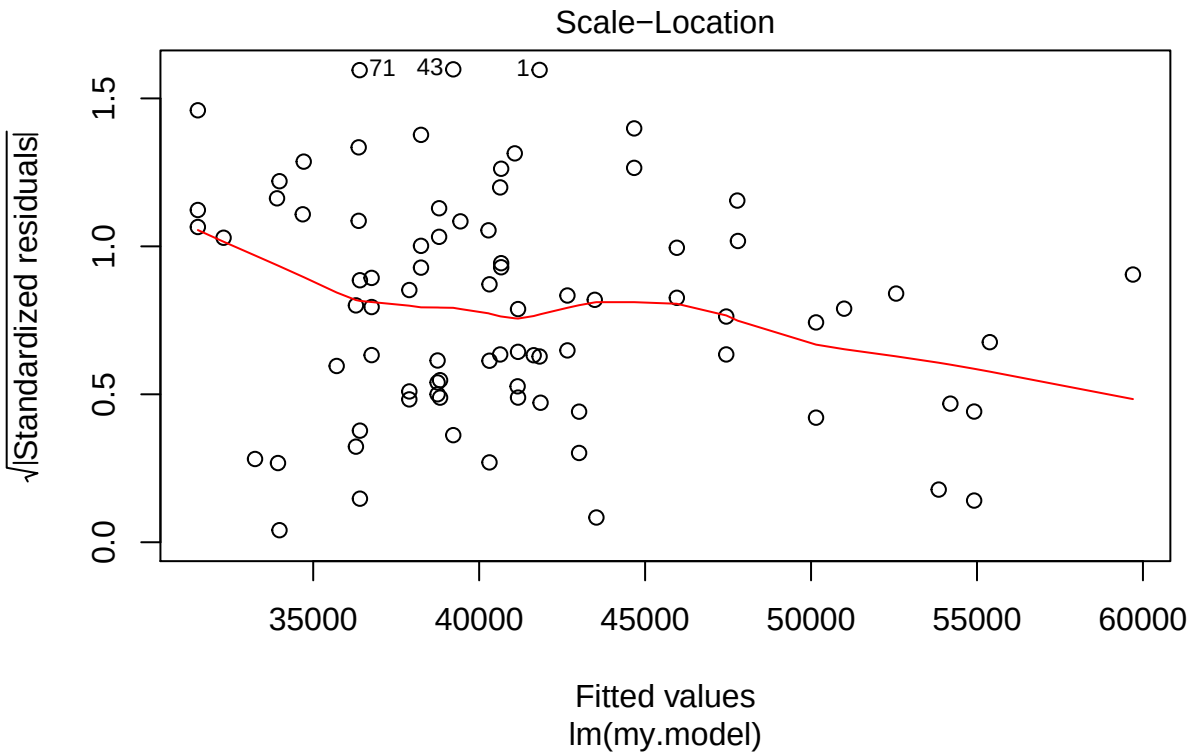
```
cat("\n","Estimated Effect of Bobblehead Promotion on Attendance: ",
round(my.model.fit$coefficients[length(my.model.fit$coefficients)],
digits = 0),"\n",sep="")
```

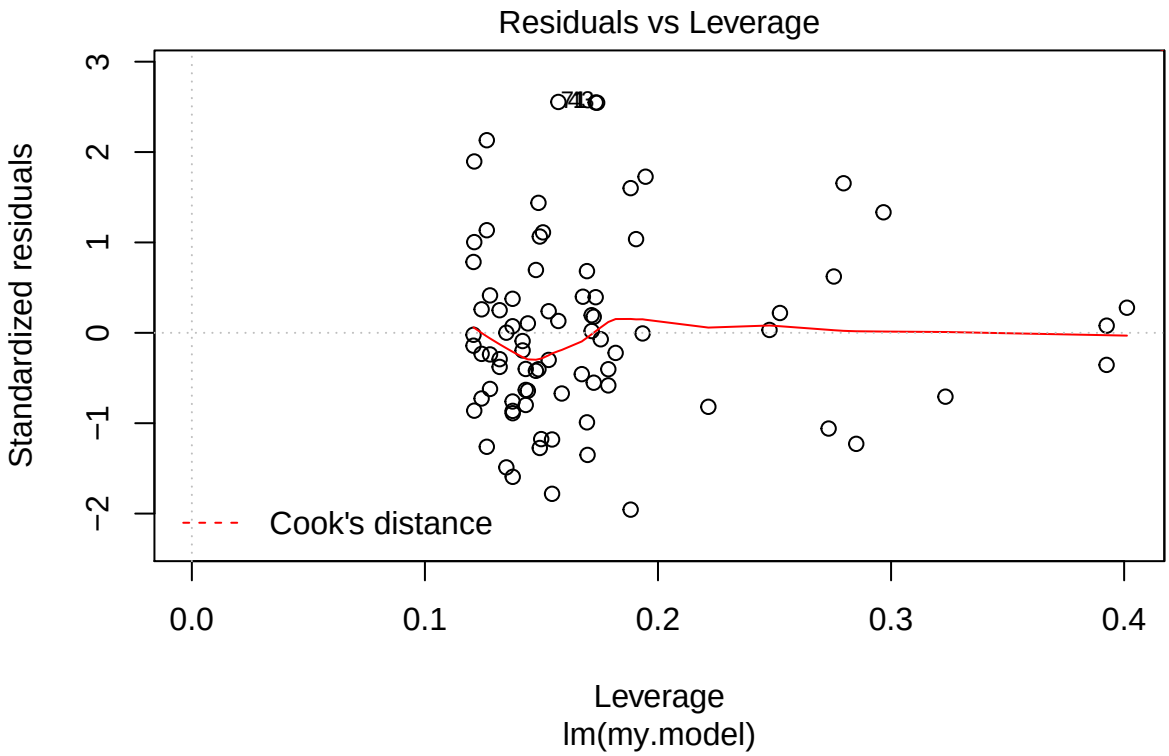
```
##
## Estimated Effect of Bobblehead Promotion on Attendance: 10715
```

```
# standard graphics provide diagnostic plots
plot(my.model.fit)
```

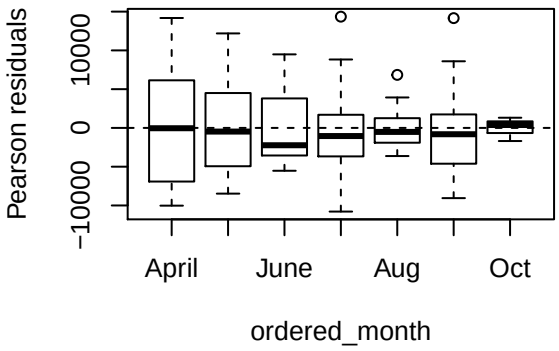

Residuals vs Fitted
Residuals
15000
5000
0
−10000
71
43
1
35000
40000
45000
50000
55000
60000
Fitted values
lm(my.model)

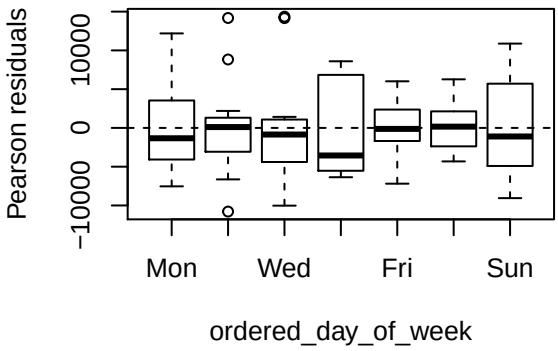

Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(my.model)
71
1
43
−2
−1
0
1
2
3

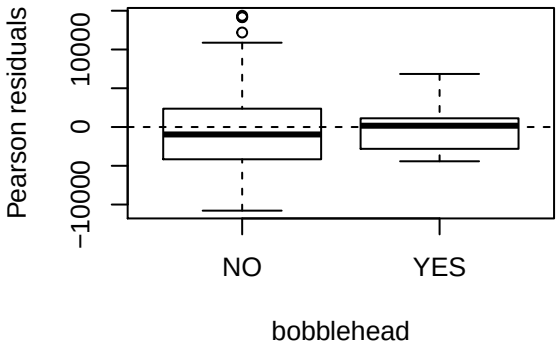

Scale−Location
71
43
1
√|Standardized residuals|
0.0
0.5
1.0
1.5
35000
40000
45000
50000
55000
60000
Fitted values
lm(my.model)

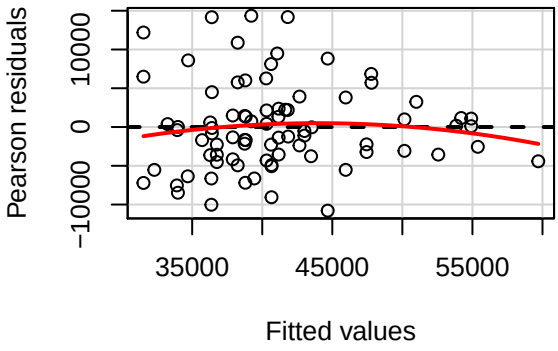



```
# additional model diagnostics drawn from the car package
library(car)
residualPlots(my.model.fit)
```





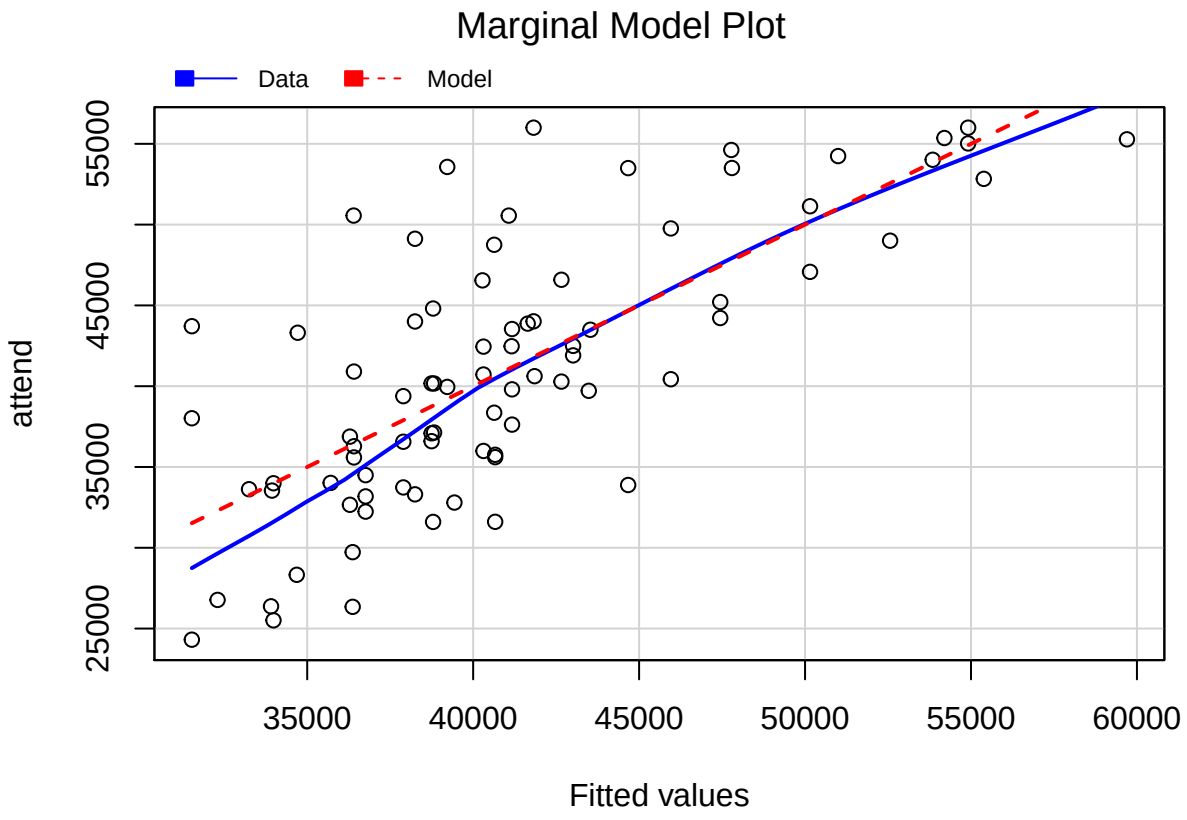





```
##                       Test stat Pr(>|t|)
## ordered_month                NA       NA
## ordered_day_of_week          NA       NA
## bobblehead                   NA       NA
## Tukey test               -1.123    0.261
```

```
marginalModelPlots(my.model.fit)
```

```
## Warning in mmps(...): Interactions and/or factors skipped
```




```
print(outlierTest(my.model.fit))
```

```
##
## No Studentized residuals with Bonferonni p < 0.05
## Largest |rstudent|:
##    rstudent unadjusted p-value Bonferonni p
## 43 2.668406          0.0095805      0.77602
```

```
# Suggestions for the student:
# Examine regression diagnostics for the fitted model.
# Examine other linear predictors and other explanatory variables.
# See if you can improve upon the model with variable transformations.
```