

# Unit 9 Homework: Large-Sample Regression Theory

w203: Statistics for Data Science

## What Makes a Successful Video Game?

The file `video_games.csv` contains data on 1212 video games that were on sold in 2011. It was compiled by Joe Cox, an economist at the University of Portsmouth.

Three key variables are as follows:

Variable	Meaning
Metrics.Sales	The total sales, measured in millions of dollars.
Metrics.Review.Score	Metacritic review score, an indicator of quality, out of 100.
Length.Completionists.Average	The mean time that players reported completing everything in the game, in hours.

You can find an explanation of other variables at [https://think.cs.vt.edu/corgis/csv/video\\_games/](https://think.cs.vt.edu/corgis/csv/video_games/).

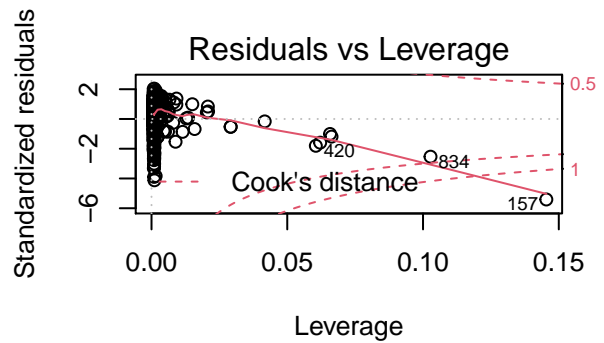
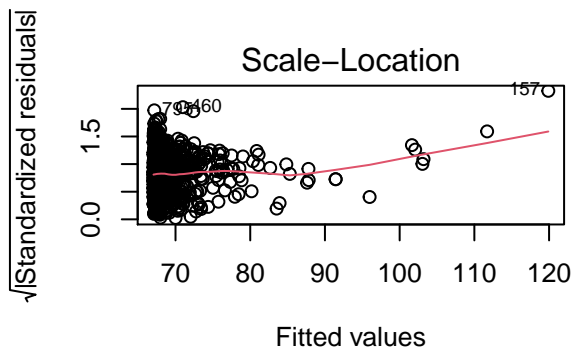
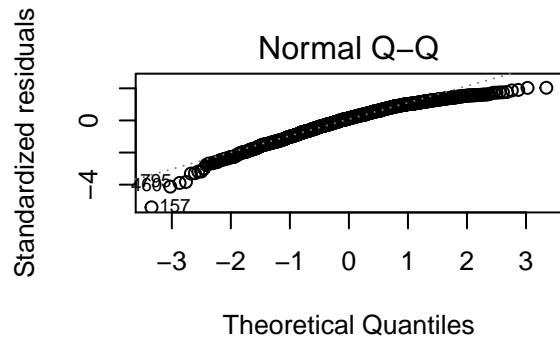
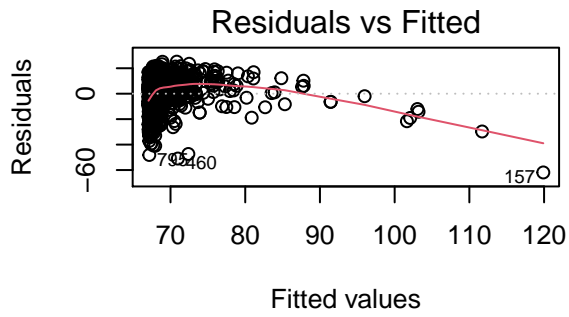
You want to fit a regression predicting `Metrics.Sales`, with `Metrics.Review.Score` and `Length.Completionists.Average` as predictors.

0. Rename the variables that you are going to use to something sensible – variable names that have both periods and capital letters are not sensible. :fire: Better would be, for example changing `Metrics.Sales` to just `sales`.
1. Examining the data, and using your background knowledge, evaluate the assumptions of the large-sample linear model.

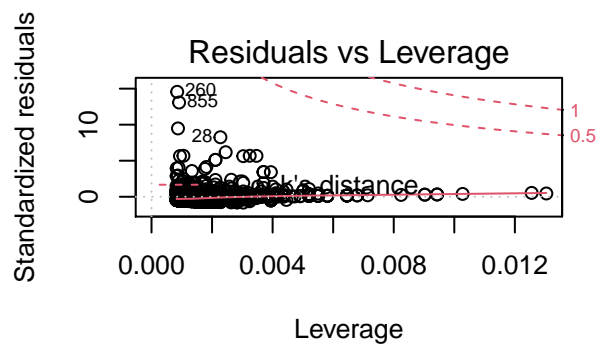
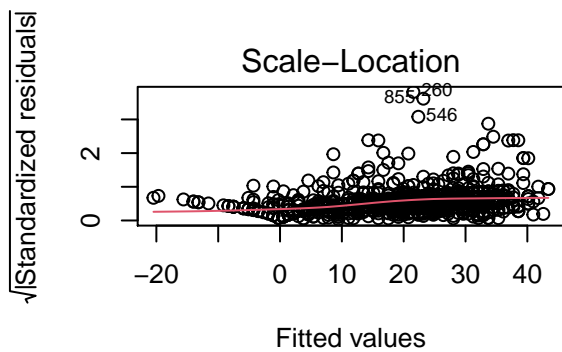
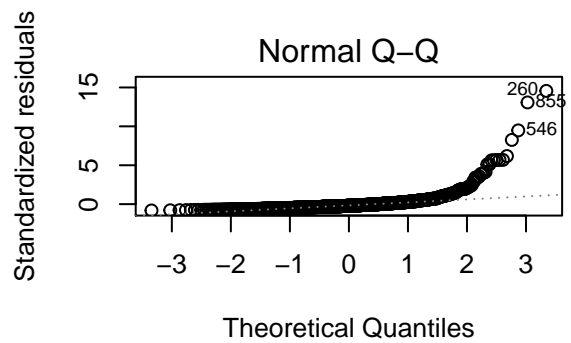
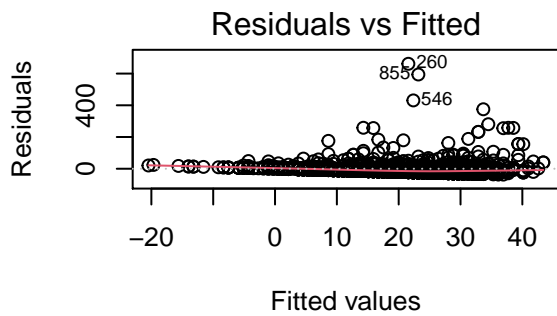
```
summary(df)
```

```
##      sales      score      length
## Min.   : 0.0100  Min.   :19.00  Min.   : 0.00
## 1st Qu.: 0.0900  1st Qu.:60.00  1st Qu.: 0.00
## Median : 0.2100  Median :70.00  Median : 6.00
## Mean   : 0.5032  Mean   :68.83  Mean   :19.81
## 3rd Qu.: 0.4600  3rd Qu.:79.00  3rd Qu.:21.55
## Max.   :14.6600  Max.   :98.00  Max.   :683.13
```

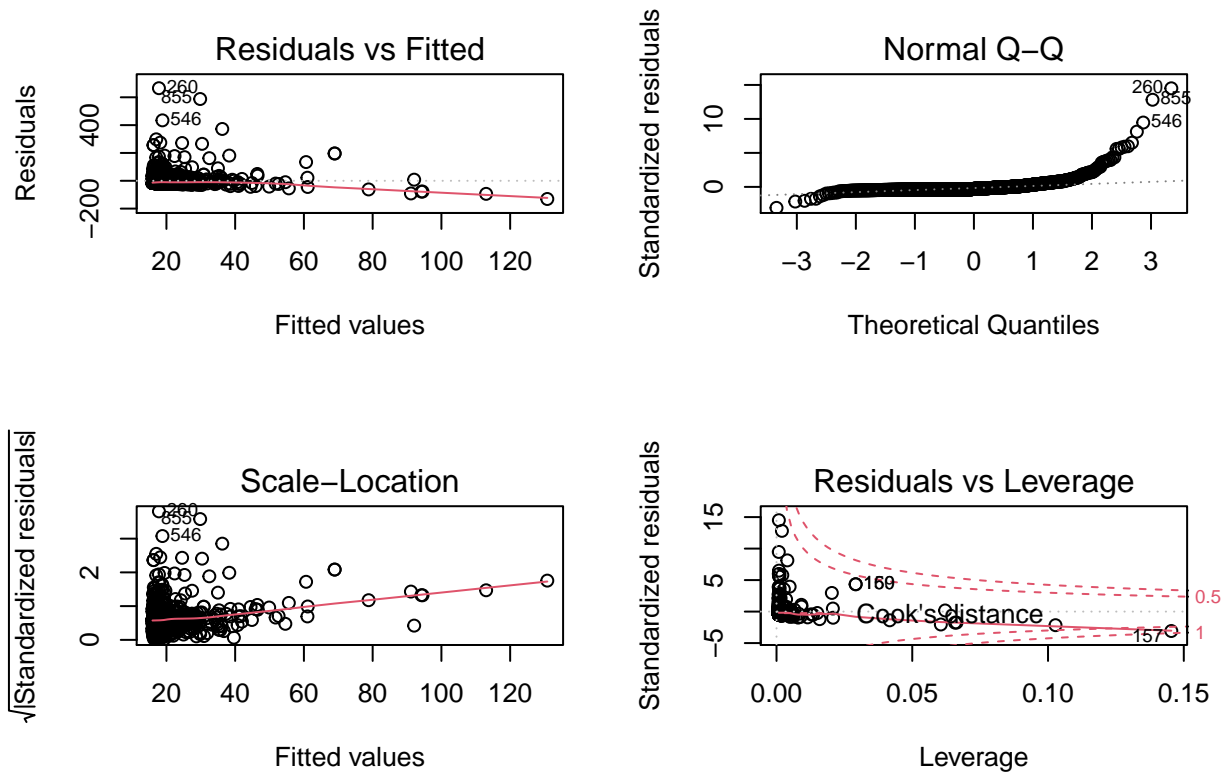
```
fit <- lm(df$score ~ df$sales)
par(mfrow=c(2,2))
plot(fit)
```



```
fit <- lm(df$length ~ df$score)
par(mfrow=c(2,2))
plot(fit)
```



```
fit <- lm(df$length ~ df$sales)
par(mfrow=c(2,2))
plot(fit)
```



- Whether you consider the large-sample linear model sufficiently valid or not, proceed to fit the linear model using `lm()`.

```
library(gvlma)

fit <- lm(df$sales ~ df$score + df$length)
gvmodel <- gvlma(fit)
summary(gvmodel)

##
## Call:
## lm(formula = df$sales ~ df$score + df$length)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.1125 -0.4223 -0.1852  0.0918 14.4534
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.0919732  0.1592648  -6.856 1.12e-11 ***
## df$score      0.0223899  0.0023092   9.696 < 2e-16 ***
## df$length     0.0027297  0.0006416   4.255 2.25e-05 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.015 on 1209 degrees of freedom
## Multiple R-squared:  0.1022, Adjusted R-squared:  0.1007
## F-statistic: 68.79 on 2 and 1209 DF,  p-value: < 2.2e-16
##
##
## ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
## USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
## Level of Significance = 0.05
##
## Call:
## gvlma(x = fit)
##
##
##              Value    p-value              Decision
## Global Stat      262748.77 0.000e+00 Assumptions NOT satisfied!
## Skewness          10030.69 0.000e+00 Assumptions NOT satisfied!
## Kurtosis          252418.54 0.000e+00 Assumptions NOT satisfied!
## Link Function         49.76 1.738e-12 Assumptions NOT satisfied!
## Heteroscedasticity    249.78 0.000e+00 Assumptions NOT satisfied!
```

```
library(car)
```

```
## Loading required package: carData
```

```
##
```

```
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
##      recode
```

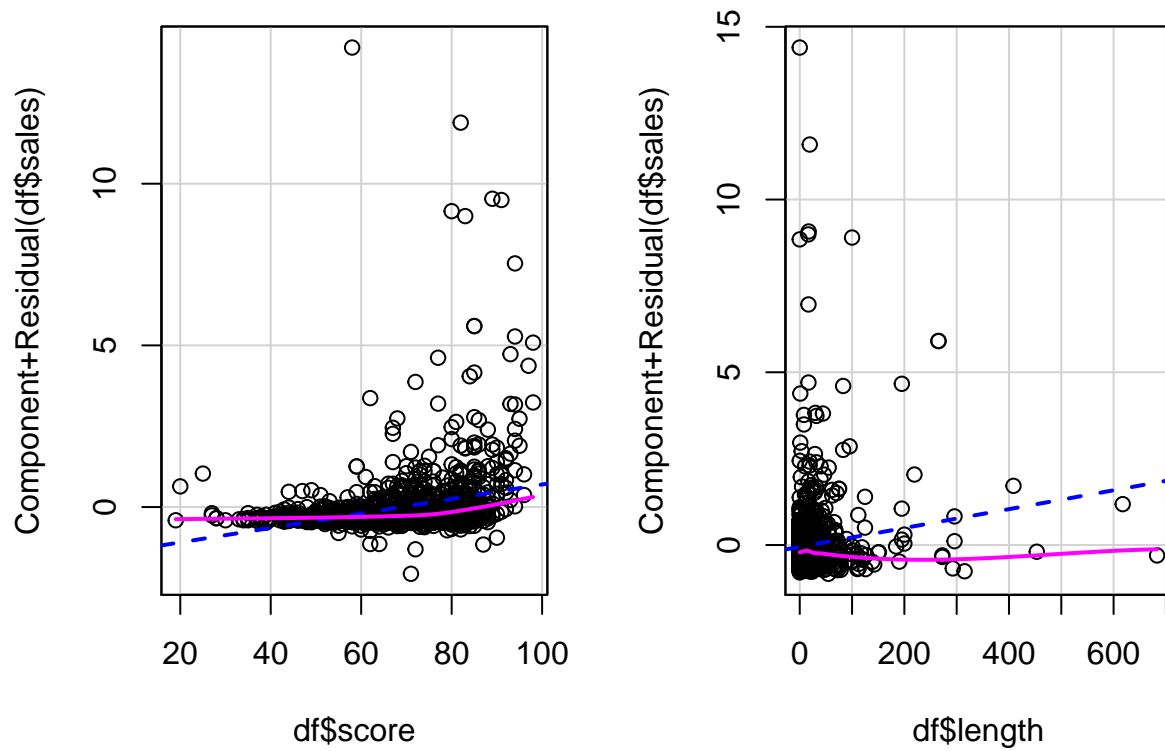
```
## The following object is masked from 'package:purrr':
```

```
##
```

```
##      some
```

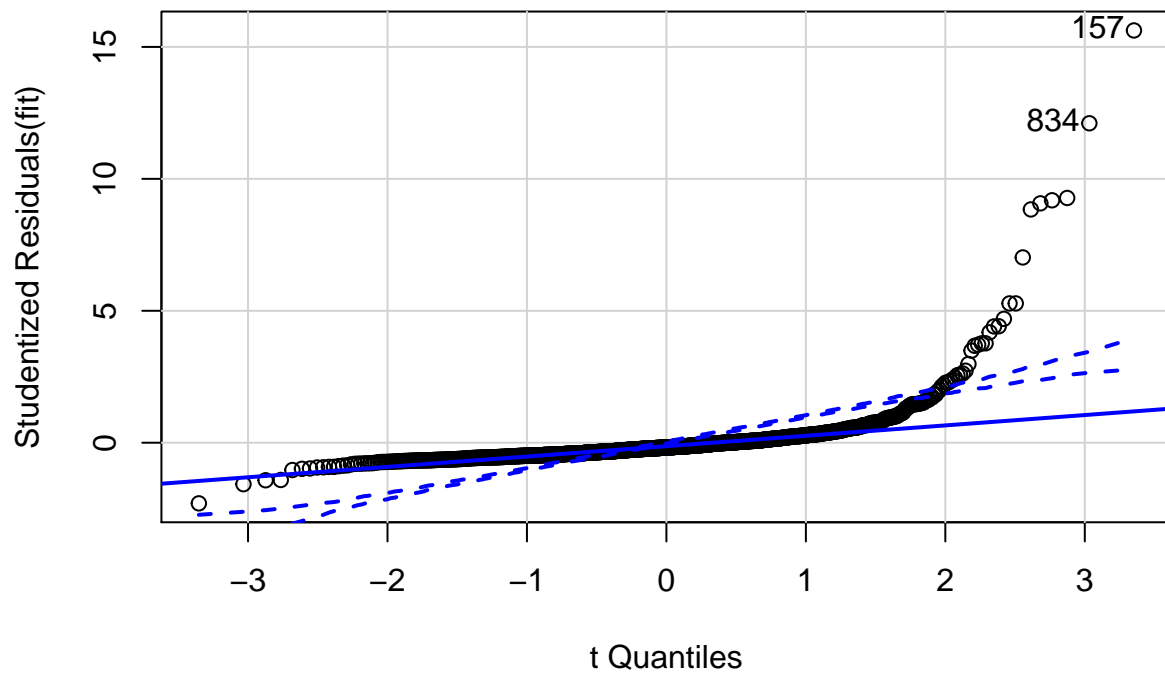
```
crPlots(fit)
```

## Component + Residual Plots



```
qqPlot(fit, labels = row.names(df), id.method = 'identify', simulate = TRUE, main = 'Q-Q Plot')
```

## Q-Q Plot



```
## [1] 157 834
```

```
ncvTest(fit)
```

```
## Non-constant Variance Score Test
## Variance formula: ~ fitted.values
## Chisquare = 386.6485, Df = 1, p = < 2.22e-16
```

```
durbinWatsonTest(fit)
```

```
## lag Autocorrelation D-W Statistic p-value
## 1 0.6379745 0.7124182 0
## Alternative hypothesis: rho != 0
```

```
vif(fit)
```

```
## df$score df$length
## 1.053108 1.053108
```

3. Examine the coefficient for Metrics.Review.Score and give an interpretation of what it means.

```
scoresales.lm <- lm(score ~ sales, data=df)
scorelength.lm <- lm(score ~ length, data=df)
summary(scoresales.lm)$r.squared
```

```
## [1] 0.0887267
```

```
summary(scorelength.lm)$r.squared
```

```
## [1] 0.05042935
```

The most common interpretation of the coefficient of determination is how well the regression model fits the observed data. For example, a coefficient of determination of 60% shows that 60% of the data fit the regression model. Generally, a higher coefficient indicates a better fit for the model.

However, it is not always the case that a high r-squared is good for the regression model. The quality of the coefficient depends on several factors, including the units of measure of the variables, the nature of the variables employed in the model, and the applied data transformation. Thus, sometimes, a high coefficient can indicate issues with the regression model.

No universal rule governs how to incorporate the coefficient of determination in the assessment of a model. The context in which the forecast or the experiment is based is extremely important, and in different scenarios, the insights from the statistical metric can vary.

```
bptest(scoresales.lm)
```

```
##
## studentized Breusch-Pagan test
##
## data: scoresales.lm
## BP = 41.037, df = 1, p-value = 1.494e-10
```

```
bptest(scorelength.lm)
```

```
##
## studentized Breusch-Pagan test
##
## data: scorelength.lm
## BP = 14.348, df = 1, p-value = 0.0001519
```

4. Perform a hypothesis test to assess whether video game quality has a relationship with total sales. Please use `vcovHC` from the `sandwich` package with the default options (“HC3”) to compute robust standard errors. To conduct the test, use `coeftest` from the `lmtest` package.

```
library(lmtest)
m1 <- lm(df$score ~ df$sales)
bptest(m1)
```

```
##
## studentized Breusch-Pagan test
##
## data: m1
## BP = 41.037, df = 1, p-value = 1.494e-10
```

```
#ptest(m1, studentsize=FALSE)
```

```
library(sandwich)
#summary(m1)
#NeweyWest(m1)

#result1<-coeftest(m1, vcov = NeweyWest(m1))
result2<-coeftest(m1, vcov. = vcovHC, type = "HC3")

print(result2)
```

```
##
## t test of coefficients:
##
##              Estimate Std. Error  t value  Pr(>|t|)
## (Intercept)  67.01333    0.51107  131.1234 < 2.2e-16 ***
## df$sales      3.60731    0.85261   4.2309 2.503e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(m1)
```

```
##
## Call:
## lm(formula = df$score ~ df$sales)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
```

```
## -61.897  -7.719    1.572   9.551  25.163
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  67.0133     0.3928  170.61  <2e-16 ***
## df$sales     3.6073     0.3323   10.85  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.37 on 1210 degrees of freedom
## Multiple R-squared:  0.08873,    Adjusted R-squared:  0.08797
## F-statistic: 117.8 on 1 and 1210 DF,  p-value: < 2.2e-16
```

5. How many more sales does your model predict for a game one standard-deviation higher than the mean review, vs. a game one standard-deviation lower than the mean review, holding all else equal? Answer this in two different ways:
  - (a) Compute the standard deviation of the review score, and multiply the appropriate model coefficient by two-times this standard deviation.
  - (b) Use the `predict` function with the model that you have estimated. You can read the documentation for `predict.lm` which is the predict method for linear model objects (the type that you have fit here). Include a data frame (that has the same variable names as the data frame that you fitted the model against) in the `newdata` argument to `predict`. This data frame should have two rows and two columns. The column for the reviews should change from  $\mu - \sigma$  to  $\mu + \sigma$ ; the column for the play time should be set to a constant, sensible level (perhaps the  $\mu$  of this variable).
5. **Optional:** Open the attached paper by Joe Cox, and read section 3. Which assumption did the author focus on, and why do you think that is?

*Note: Maximum score on any homework is 100%*