Case Solution 1 Group 5

Balint Keller

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Hypothesis Testing

H_0: $\beta_2 = 0 \rightarrow$ Education has no effect on wages.

H_1: $\beta_2 > 0 \rightarrow$ Education has a positive effect on wages.

One-sided hypotheses are appropriate in this case because education is expected to increase earnings (according to economic theories).
In addition, there's often little reason to test whether more education reduces wages because that result is counterintuitive.

```
head(df)
```

```
##       WAGE EDUC AGE RACE SMSA MARRIED REGION QOB
## 1 580.1000    9  45    0    0       1      9   3
## 2 642.2115   17  47    0    0       1      3   4
## 3 577.0192   12  42    0    0       1      7   2
## 4 999.1346   10  43    0    0       1      3   2
## 5 307.7885   12  41    0    0       1      6   3
## 6 280.1000   12  40    1    0       1      5   2
```

```
#Creation of dummy vars for the regions and QOBs
REGION2 = ifelse(df$REGION == 2, 1, 0)
REGION3 = ifelse(df$REGION == 3, 1, 0)
REGION4 = ifelse(df$REGION == 4, 1, 0)
REGION5 = ifelse(df$REGION == 5, 1, 0)
REGION6 = ifelse(df$REGION == 6, 1, 0)
REGION7 = ifelse(df$REGION == 7, 1, 0)
REGION8 = ifelse(df$REGION == 8, 1, 0)
REGION9 = ifelse(df$REGION == 9, 1, 0)

QOB2 = ifelse(df$QOB == 2, 1, 0)
QOB3 = ifelse(df$QOB == 3, 1, 0)
QOB4 = ifelse(df$QOB == 4, 1, 0)
```

```
summary(df)
```

```
##       WAGE                EDUC            AGE             RACE
##  Min.   :    0.096   Min.   : 0.00   Min.   :40.00   Min.   :0.0000
##  1st Qu.:  278.558   1st Qu.:12.00   1st Qu.:42.00   1st Qu.:0.0000
##  Median :  384.712   Median :12.00   Median :45.00   Median :0.0000
```

```
##  Mean   :  436.524   Mean   :12.71   Mean   :44.68   Mean   :0.0832
##  3rd Qu.:  520.100   3rd Qu.:15.00   3rd Qu.:47.00   3rd Qu.:0.0000
##  Max.   :10167.500   Max.   :20.00   Max.   :50.00   Max.   :1.0000
##       SMSA            MARRIED           REGION           QOB
##  Min.   :0.0000   Min.   :0.0000   Min.   :1.000   Min.   :1.000
##  1st Qu.:0.0000   1st Qu.:1.0000   1st Qu.:3.000   1st Qu.:1.000
##  Median :0.0000   Median :1.0000   Median :5.000   Median :3.000
##  Mean   :0.1813   Mean   :0.8609   Mean   :4.767   Mean   :2.502
##  3rd Qu.:0.0000   3rd Qu.:1.0000   3rd Qu.:7.000   3rd Qu.:3.000
##  Max.   :1.0000   Max.   :1.0000   Max.   :9.000   Max.   :4.000
```

```
describe(df)
```

```
##         vars     n   mean     sd median trimmed    mad  min     max   range
## WAGE       1 10000 436.52 295.37 384.71  401.88 173.27  0.1 10167.5 10167.4
## EDUC       2 10000  12.71   3.28  12.00   12.72   2.97  0.0    20.0    20.0
## AGE        3 10000  44.68   2.93  45.00   44.67   4.45 40.0    50.0    10.0
## RACE       4 10000   0.08   0.28   0.00    0.00   0.00  0.0     1.0     1.0
## SMSA       5 10000   0.18   0.39   0.00    0.10   0.00  0.0     1.0     1.0
## MARRIED    6 10000   0.86   0.35   1.00    0.95   0.00  0.0     1.0     1.0
## REGION     7 10000   4.77   2.46   5.00    4.65   2.97  1.0     9.0     8.0
## QOB        8 10000   2.50   1.12   3.00    2.50   1.48  1.0     4.0     3.0
##          skew kurtosis   se
## WAGE     7.39   170.46 2.95
## EDUC    -0.07     0.55 0.03
## AGE      0.05    -1.18 0.03
## RACE     3.02     7.11 0.00
## SMSA     1.65     0.74 0.00
## MARRIED -2.09     2.35 0.00
## REGION   0.35    -1.06 0.02
## QOB     -0.03    -1.35 0.01
```

```
cov(df)
```

```
##                 WAGE         EDUC          AGE          RACE          SMSA
## WAGE    87241.083600 315.76840618  5.256929832 -10.489999823 -14.857655185
## EDUC      315.768406  10.74170681 -0.667730053  -0.137551835  -0.188239544
## AGE         5.256930  -0.66773005  8.591725483  -0.004168257  -0.023550665
## RACE      -10.490000  -0.13755184 -0.004168257   0.076285389  -0.003784538
## SMSA      -14.857655  -0.18823954 -0.023550665  -0.003784538   0.148445155
## MARRIED    10.178375   0.02177522  0.021109281  -0.010827963   0.005419372
## REGION      8.855041   0.27408261 -0.125475448   0.001185719   0.032646165
## QOB         2.397402   0.11745439 -0.386878218  -0.003758456  -0.004794949
##               MARRIED       REGION          QOB
## WAGE    10.178375046  8.855041195  2.397401999
## EDUC     0.021775218  0.274082608  0.117454385
## AGE      0.021109281 -0.125475448 -0.386878218
## RACE    -0.010827963  0.001185719 -0.003758456
## SMSA     0.005419372  0.032646165 -0.004794949
## MARRIED  0.119763166 -0.022112511 -0.002785989
## REGION  -0.022112511  6.064117412 -0.002457546
## QOB     -0.002785989 -0.002457546  1.244520842
```

```r
cor(df)
```

```
##                 WAGE        EDUC          AGE         RACE        SMSA
## WAGE     1.000000000  0.32619065  0.006071996 -0.128586174 -0.13055898
## EDUC     0.326190646  1.00000000 -0.069506286 -0.151952924 -0.14907033
## AGE      0.006071996 -0.06950629  1.000000000 -0.005148653 -0.02085355
## RACE    -0.128586174 -0.15195292 -0.005148653  1.000000000 -0.03556389
## SMSA    -0.130558976 -0.14907033 -0.020853549 -0.035563888  1.00000000
## MARRIED  0.099576370  0.01919836  0.020809977 -0.113282921  0.04064474
## REGION   0.012174363  0.03395948 -0.017383401  0.001743320  0.03440847
## QOB      0.007275775  0.03212414 -0.118313144 -0.012197973 -0.01115578
##              MARRIED        REGION           QOB
## WAGE     0.099576370  0.0121743634  0.0072757748
## EDUC     0.019198364  0.0339594799  0.0321241395
## AGE      0.020809977 -0.0173834013 -0.1183131440
## RACE    -0.113282921  0.0017433201 -0.0121979735
## SMSA     0.040644736  0.0344084693 -0.0111557799
## MARRIED  1.000000000 -0.0259473274 -0.0072163338
## REGION  -0.025947327  1.0000000000 -0.0008945749
## QOB     -0.007216334 -0.0008945749  1.0000000000
```

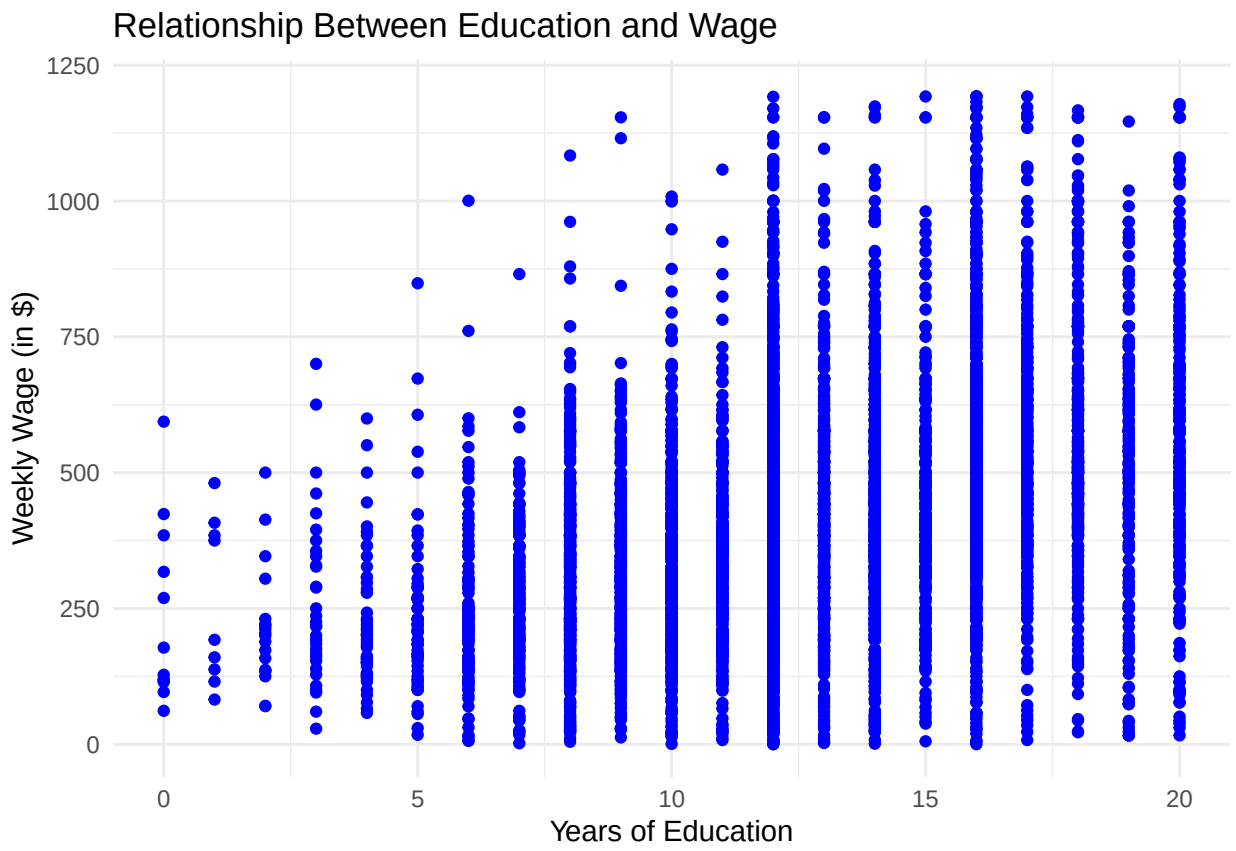
```r
ggplot(df, aes(x = df$EDUC, y = df$WAGE)) +
  geom_point(color = "blue") +
  labs(title = "Relationship Between Education and Wage",
       x = "Years of Education",
       y = "Weekly Wage (in $)") + ylim(0, 1200) +

  theme_minimal()
```

```
## Warning: Use of `df$EDUC` is discouraged.
## i Use `EDUC` instead.
```

```
## Warning: Use of `df$WAGE` is discouraged.
## i Use `WAGE` instead.
```

```
## Warning: Removed 235 rows containing missing values or values outside the scale range
## (`geom_point()`).
```




```
#linear model

linear_model1=lm(df$WAGE~ df$EDUC + df$AGE + df$RACE + df$SMSA + df$MARRIED + REGION2 + REGION3 + REGIO
stargazer(linear_model1,type="text",style="all")
```

```
##
## ===================================================
##                            Dependent variable:
##                        --------------------------
##                                   WAGE
## ---------------------------------------------------
## EDUC                             26.729***
##                                   (0.869)
##                                  t = 30.741
##                                   p = 0.000
## AGE                               2.226**
##                                   (0.953)
##                                   t = 2.335
##                                   p = 0.020
## RACE                            -77.478***
##                                  (10.229)
##                                  t = -7.574
##                                   p = 0.000
## SMSA                            -63.654***
##                                   (7.395)
```

```
##                                t = -8.608
##                                 p = 0.000
## MARRIED                        77.927***
##                                 (8.028)
##                                 t = 9.706
##                                 p = 0.000
## REGION2                        41.204***
##                                (13.645)
##                                 t = 3.020
##                                 p = 0.003
## REGION3                        49.071***
##                                (13.307)
##                                 t = 3.688
##                                p = 0.0003
## REGION4                         18.633
##                                (15.605)
##                                 t = 1.194
##                                 p = 0.233
## REGION5                          4.120
##                                (13.495)
##                                 t = 0.305
##                                 p = 0.761
## REGION6                          7.512
##                                (16.126)
##                                 t = 0.466
##                                 p = 0.642
## REGION7                         16.675
##                                (14.652)
##                                 t = 1.138
##                                 p = 0.256
## REGION8                         15.916
##                                (17.110)
##                                 t = 0.930
##                                 p = 0.353
## REGION9                        63.543***
##                                (14.048)
##                                 t = 4.523
##                                p = 0.00001
## QOB2                            -3.940
##                                 (7.942)
##                                t = -0.496
##                                 p = 0.620
## QOB3                             4.786
##                                 (7.692)
##                                 t = 0.622
##                                 p = 0.534
## QOB4                            -3.725
##                                 (7.871)
##                                t = -0.473
##                                 p = 0.637
## Constant                       -80.593*
##                                (47.936)
##                                t = -1.681
##                                 p = 0.093
```

```
## ---------------------------------------------------------
## Observations                          10,000
## R2                                     0.134
## Adjusted R2                            0.133
## Residual Std. Error               275.047 (df = 9983)
## F Statistic          96.743*** (df = 16; 9983) (p = 0.000)
## =========================================================
## Note:                           *p<0.1; **p<0.05; ***p<0.01
```

Betekenis coef

EDUC (26.729, $p < 0.001$)

A one-year increase in education leads to a $26.73 increase in wages.

This is highly significant ($p = 0.000$).

AGE (2.226, $p = 0.020$)

A one-year increase in age increases wages by $2.23.

Significant at the 5% level ($p = 0.020$).

RACE (-77.478, $p < 0.001$)

Suggests a wage penalty of $77.48 for certain racial groups (assuming a binary variable where non-white = 1).

Highly significant ($p = 0.000$).

SMSA (-63.654, $p < 0.001$)

Living in an SMSA (Standard Metropolitan Statistical Area) is associated with a $63.65 lower wage.

Significant at $p = 0.000$.

MARRIED (77.927, $p < 0.001$)

Being married increases wages by $77.93.

Highly significant ($p = 0.000$).

Regional Effects on Wages Significant Regions:

REGION2 (= 41.204, $p = 0.003$)

REGION3 (= 49.071, $p = 0.0003$)

REGION9 (= 63.543, $p = 0.00001$)

These regions have higher wages compared to the reference region.

Non-Significant Regions:

REGION4, REGION5, REGION6, REGION7, REGION8 ($p > 0.05$)

These regions do not significantly differ from the reference region in terms of wages.

```r
# Joint significance test: Test whether AGE, RACE, MARRIED, and SMSA jointly contribute to explaining W
linearHypothesis(linear_model1, c("df$AGE = 0", "df$RACE = 0", "df$MARRIED = 0", "df$SMSA = 0"))
```

```
##
## Linear hypothesis test:
## df$AGE = 0
```

```
## df$RACE = 0
## df$MARRIED = 0
## df$SMSA = 0
##
## Model 1: restricted model
## Model 2: df$WAGE ~ df$EDUC + df$AGE + df$RACE + df$SMSA + df$MARRIED +
##     REGION2 + REGION3 + REGION4 + REGION5 + REGION6 + REGION7 +
##     REGION8 + REGION9 + QOB2 + QOB3 + QOB4
##
##   Res.Df       RSS Df Sum of Sq     F    Pr(>F)
## 1   9987 773377834
## 2   9983 755224625  4  18153209 59.99 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

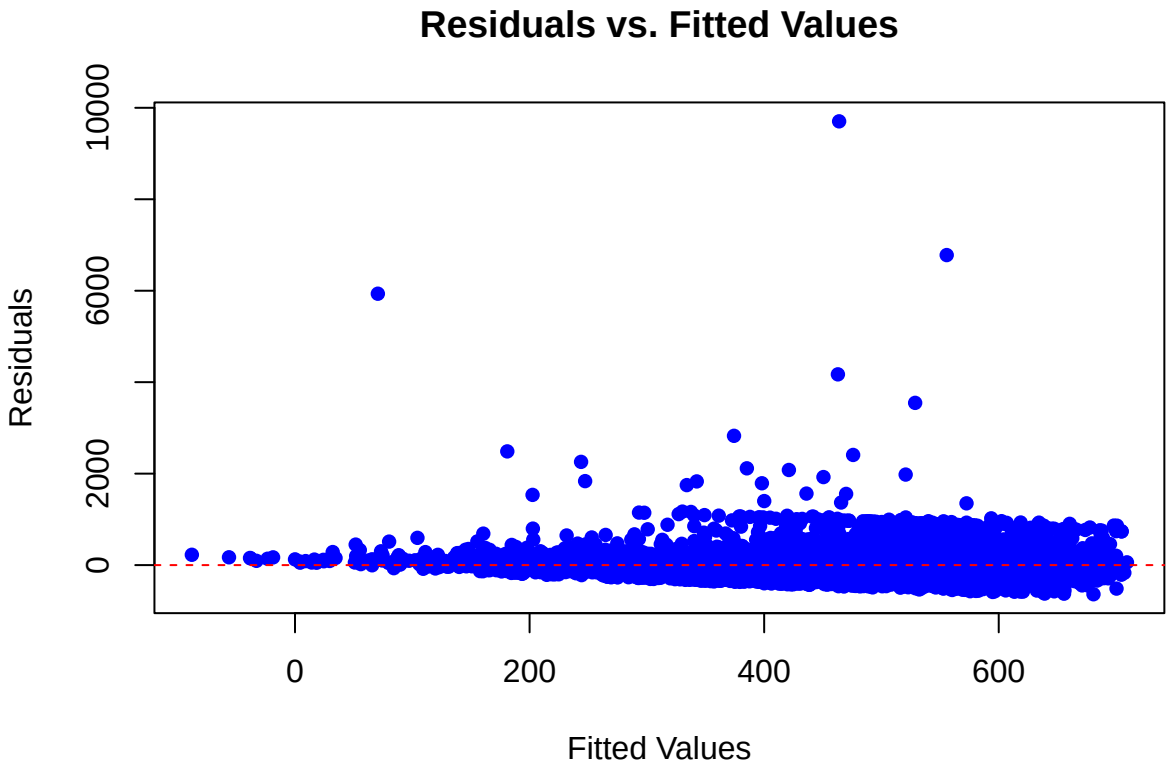
```
#Assess whether regional differences are statistically significant.
linearHypothesis(linear_model1, c("REGION2 = 0","REGION3 = 0", "REGION4 = 0", "REGION5 = 0", "REGION6 =
```

```
##
## Linear hypothesis test:
## REGION2 = 0
## REGION3 = 0
## REGION4 = 0
## REGION5 = 0
## REGION6 = 0
## REGION7 = 0
## REGION8 = 0
## REGION9 = 0
##
## Model 1: restricted model
## Model 2: df$WAGE ~ df$EDUC + df$AGE + df$RACE + df$SMSA + df$MARRIED +
##     REGION2 + REGION3 + REGION4 + REGION5 + REGION6 + REGION7 +
##     REGION8 + REGION9 + QOB2 + QOB3 + QOB4
##
##   Res.Df       RSS Df Sum of Sq      F   Pr(>F)
## 1   9991 759835148
## 2   9983 755224625  8   4610523 7.6181 3.28e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

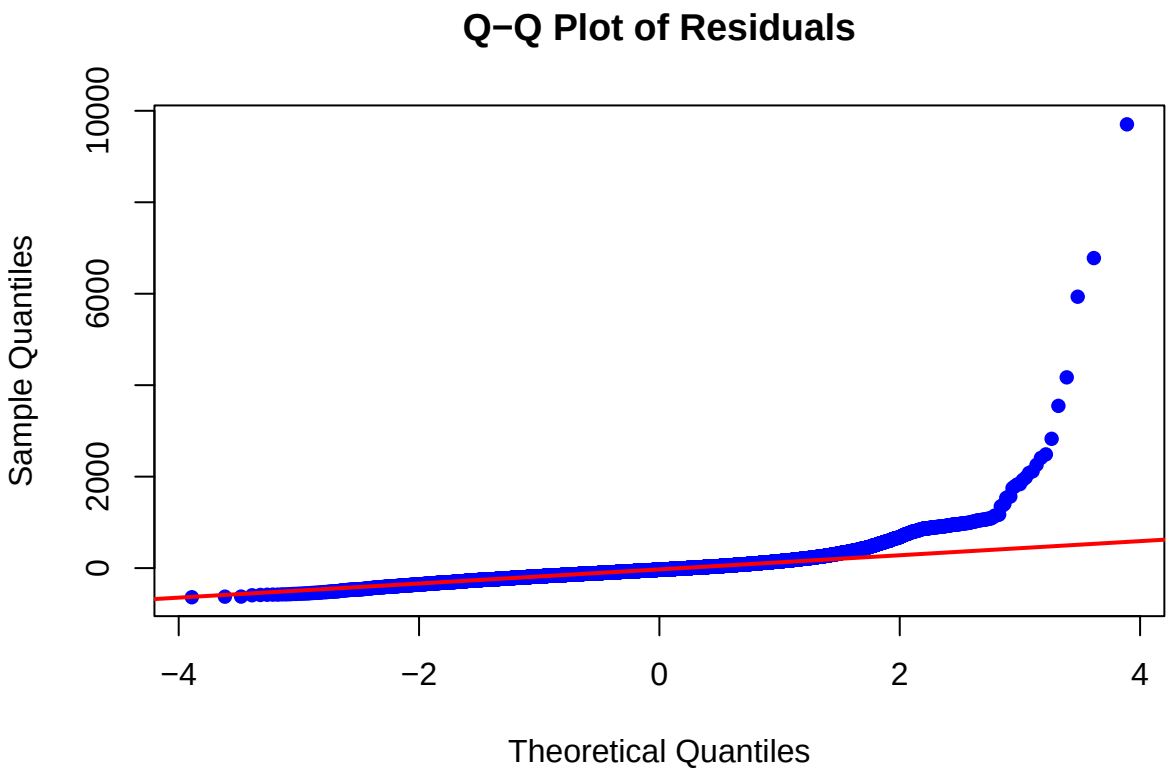
Since the p-value is extremely small (<0.001), we reject the null hypothesis. This means that at least one of the region coefficients is significantly different from zero, implying that region does have a statistically significant effect on wages.

MKV 1: EDC en AGE zijn stochastic, dummy variables zijn deterministic

```
plot(linear_model1$fitted.values, resid(linear_model1),
     main = "Residuals vs. Fitted Values",
     xlab = "Fitted Values",
     ylab = "Residuals",
     pch = 16, col = "blue")
abline(h = 0, lty = 2, col = "red")  # Add a reference line at zero
```

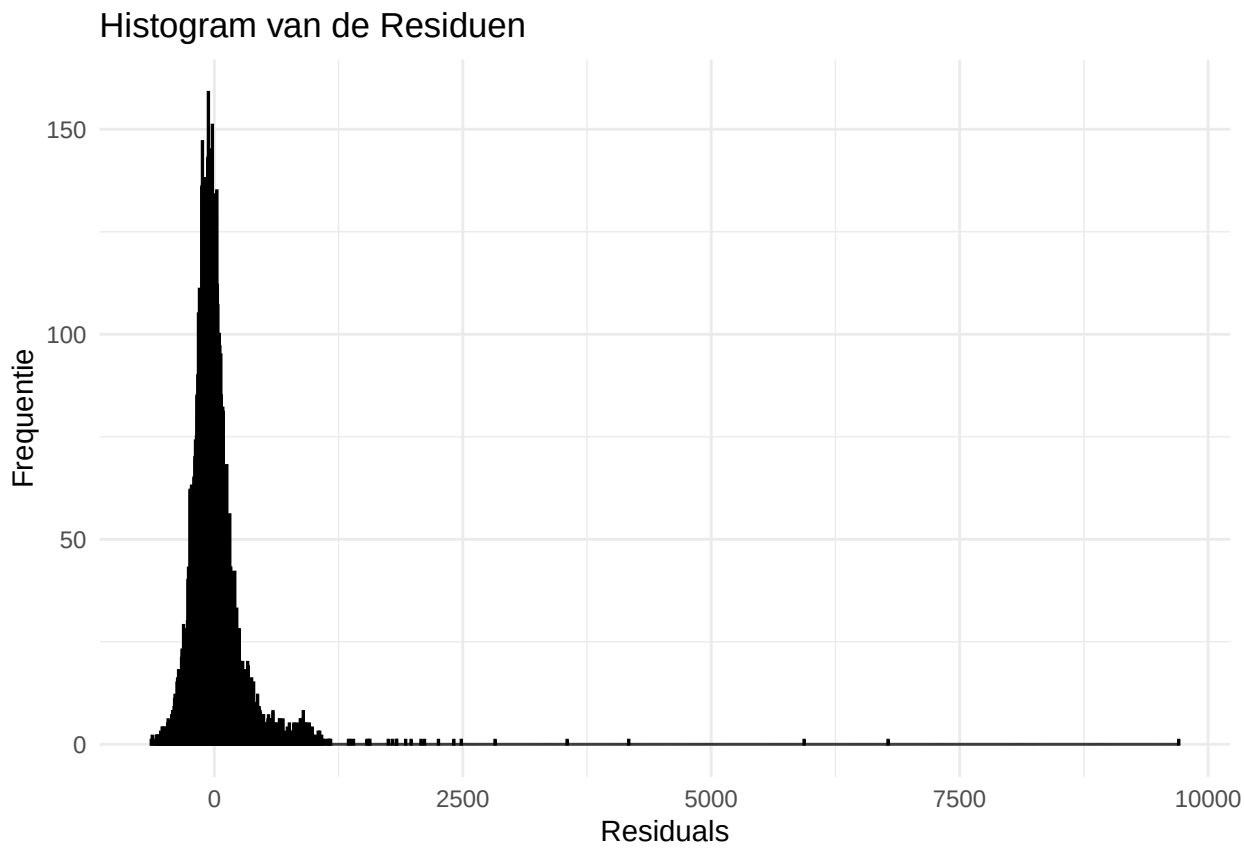



```r
qqnorm(resid(linear_model1), main = "Q-Q Plot of Residuals", pch = 16, col = "blue")
qqline(resid(linear_model1), col = "red", lwd = 2)  # Add a reference line
```

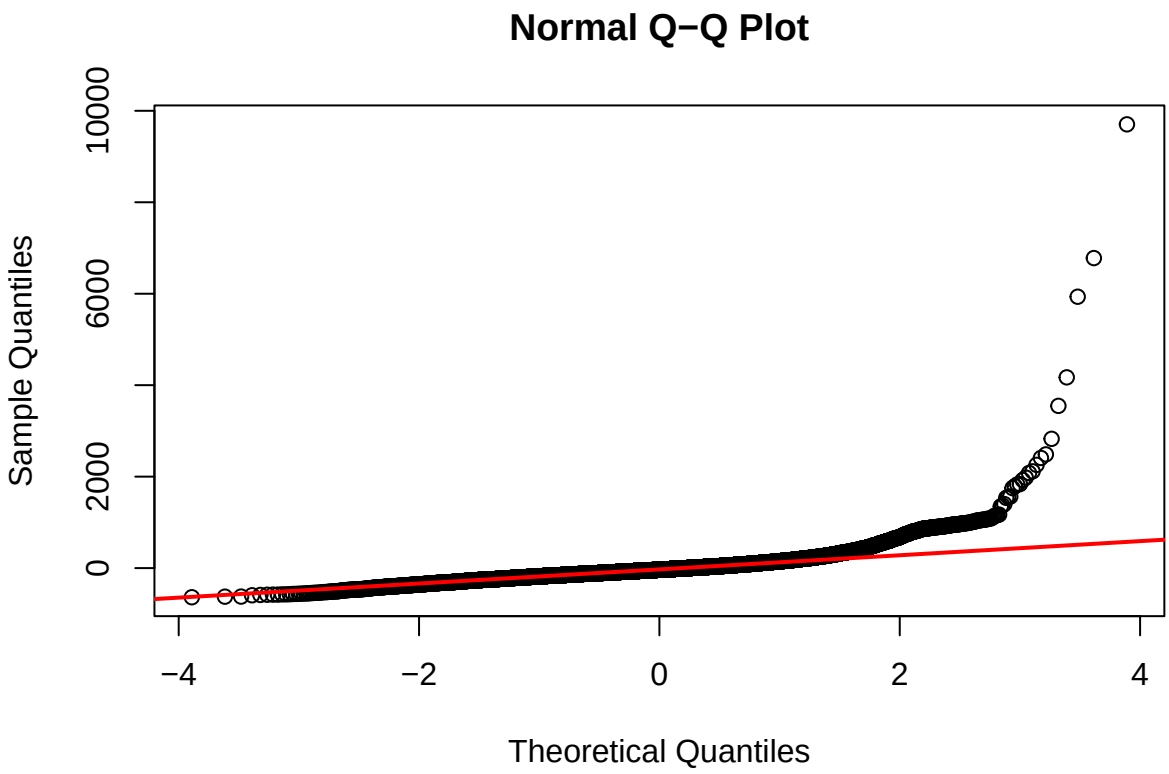



```r
# Updated upstream


# Residuen opslaan
residuals <- residuals(linear_model1)
# Histogram van de residuen
ggplot(data.frame(residuals), aes(x = residuals)) +
  geom_histogram(binwidth = 5, color = "black", fill = "blue", alpha = 0.7) +
  labs(title = "Histogram van de Residuen", x = "Residuals", y = "Frequentie") +
  theme_minimal()
```




```r
# Q-Q plot
qqnorm(residuals)
qqline(residuals, col = "red", lwd = 2)
```




```
# Jarque-Bera test uitvoeren
jarque.bera.test(residuals)
```

```
##
##  Jarque Bera Test
##
## data:  residuals
## X-squared = 21719878, df = 2, p-value < 2.2e-16
```

«««< Updated upstream Gauss-Markov assumptions:

Assumption 1: Linearity in the parameters: CHECK

Assumption 2a: The X -values are fixed over repeated sampling (fixed regressor model)

EDUC AGE 1 1

```
print(mean(residuals))
```

```
## [1] -4.164089e-15
```

```
print(t.test(residuals, mu = 0))
```

```
##
##  One Sample t-test
```

```
##
## data:  residuals
## t = -1.5152e-15, df = 9999, p-value = 1
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -5.387167  5.387167
## sample estimates:
##     mean of x
## -4.164089e-15
```

```
if (show_interpretation) {
  cat("Assumption 3: The expected V value of the error terms  i is zero: CHECK")
}
```

```
## Assumption 3: The expected V value of the error terms  i is zero: CHECK
```

Since the p value is small, we reject the null hypothesis .Therefore the residuals are NOT normally distributed

```
bptest(linear_model1)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  linear_model1
## BP = 8.9621, df = 16, p-value = 0.915
```

euuhhh , deze test zegt dat er geen heteroskedasticity is , maar onze residuals zijn wel niet nrml verdeeld lol . geen idee hoe ik verder moet