GLM Assignment 2

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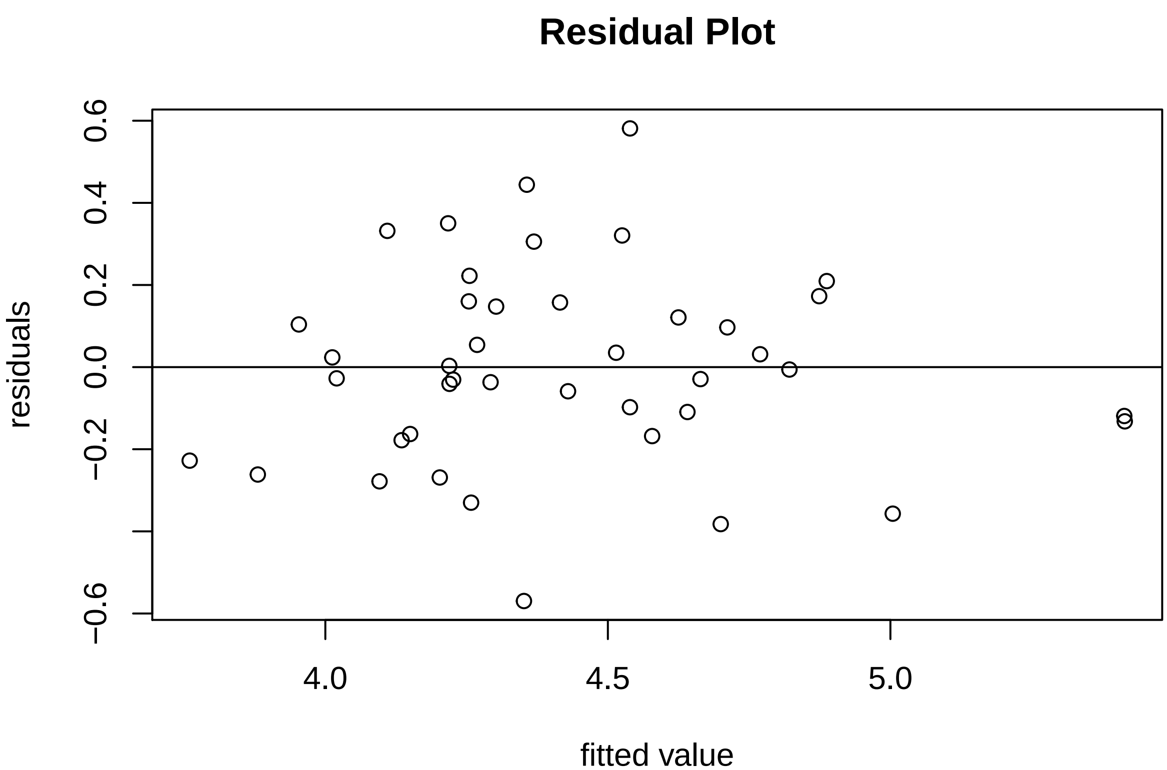
1. Fit a linear regression model to the data. What variables are most predictive for the crime rate?

As a set of variable, **Age, Education, Ex0, U2 and X** are most effective linear model covariates for the crime rate.

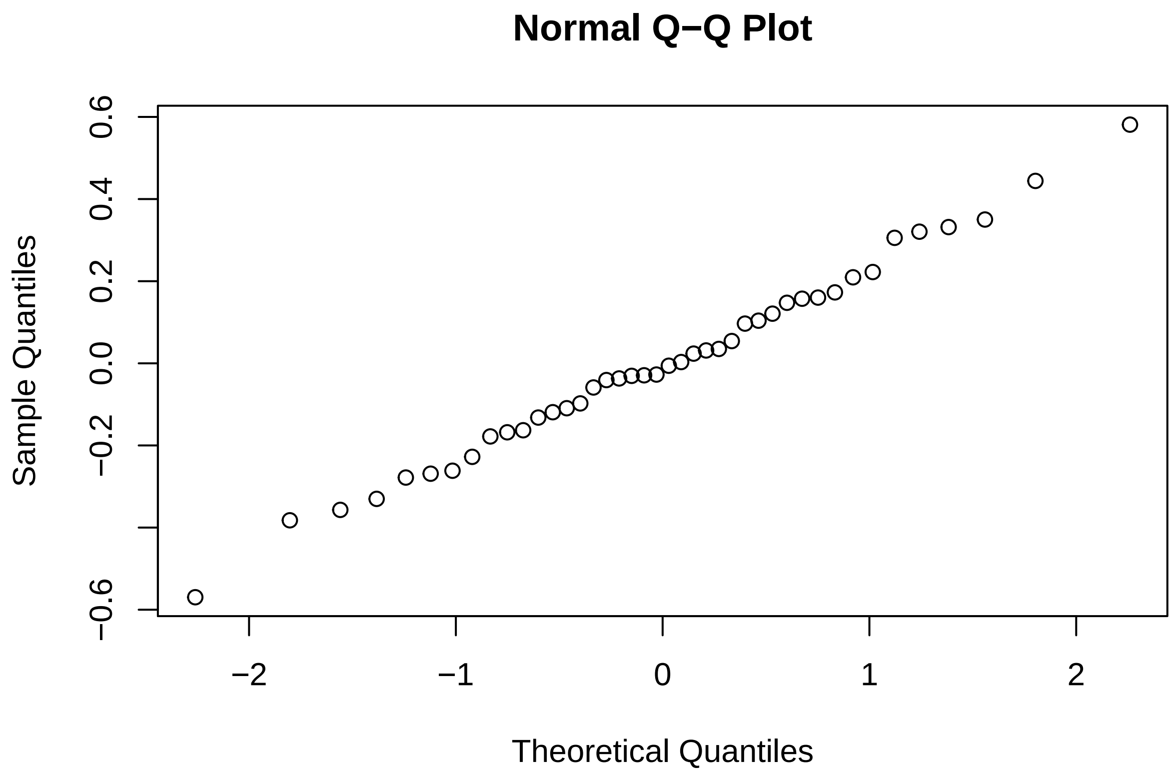
R = -2.310635+0.012725*Age + 0.021344*Ed + 0.012930*Ex0 + 0.009798*U2 + 0.006608*X

- I read table and fitted the full model(fit1). By stepwise function, I selected variables.(fit2) __ ANOVA ensured smaller model is more adequate with p-value 0.9021.
- Comparing AIC by drop1 function, I dropped covariate 'M'.(fit3)
- I checked scatter Plot Matrix and correlation matrix. I deleted insignificant covariate U1 which has the Multicollinearity with U2.(fit4)
- ANOVA ensured smallest model(fit4) is better than fit3.
- Residual plot implies nonconstant variance. I conduct log transformation on Y.
- It seems there is no influence point by checking cooks distance.

```
crime.dat <- read.table("~/Library/Mobile Documents/com~apple~CloudDocs/crime.dat.txt", header = T)
crime.dat<-na.omit(crime.dat)
fit4<-lm(log(R) ~ Age + Ed + Ex0  + U2 + X, data=crime.dat)
plot(fitted(fit4), resid(fit4), main="Residual Plot",
     xlab="fitted value", ylab="residuals")
abline(a=0,b=0)
```



```r
qqnorm(resid(fit4))
```



It seems that the model satisfy the assumptions for the linear model pretty well.

2. A crime rate may be viewed as "high" if it is above 105 and "low" otherwise.

Fit a logistic regression model to the data. What variables are most predictive for a "high" crime rate?

As a set of variable, **Age , Ex1 , LF , NW , U2 , X** are most effective quasibinomial model covariates for the crime rate.

R1<-as.numeric(R>105).

R1= -224.80112 +0.49310*Age+0.36407*Ex1 +0.11835*LF+-0.05242*NW+ 0.36543*U2+0.25849*X

- I conducted logit model on the data, but it didn't converge.(fit1_bin)
- After stepwise variable selection, the model didnt' converge.(fit2_bin)
- Comparing AIC by drop1 function, I droped U1 which increase smallest AIC and cure multicollinearity between U1 and U2. And this model converge.(fit3_bin)
- I checked dispersion parameter by fitting quasibinomial model, and dispersion parameter for quasi model is 0.4. (fit4_bin_quasi)
- As dispersion parameter is not near 1, it turns out that binomial model not fit well, so we use quasibinomial model.
- It seems there some influence points by checking cooks distance. As there are more than 4, we regard those as parts of data.

3. Round off crime rate numbers to the nearest integers and then fit a Poisson GLM to the new crime rate data. What variables are most predictive for the crime rate? Does the Poisson GLM fit the data well?

As a set of variable, **Age , Ed, Ex0 , U2, W, X** are most effective quasibinomial model covariates for the crime rate.

R2<-round(R,digits=0)

R2 = -2.967425+0.012161Age+0.015589Ed +0.009611Ex0 +0.007522U2 +0.002311W+0.009295X

- Full poisson model (fit1_poi) has many insignificant covariates.
- After stepwise variable selection, the model has smaller explanatory variable.(fit2_poi)
- The covariate LF of fit2 model has significant but largest P-value. By conducting ANOVA and checking AIC by drop function, I dropped LF covariate.(fit3_poi)
- By drop1 function, I droped U1 which increase the smallest amount of AIC, and has multicollinearity with U2.(fit4_poi) ANOVA test ensures that model without U1 might me better.
- I checked dispersion parameter by fitting quasipoisson model, and dispersion parameter for quasi model is 5.3. (fit4_poi_quasi)
- As dispersion parameter is not near 1, it turns out that binomial model not fit well, so we use quasibinomial model.

4. Compare the results from 1) – 3), and comment on what you find. What do you learn from the analysis? What is your final conclusion?

table1: Equation for each model.

Model	Equation
Linear model	R ~ Age + U2 + X + Ex0 + Ed
Quasibinomial	R1 ~ Age + U2 + X + Ex1 + LF + NW
Quasipoisson	R2 ~ Age + U2 + X + Ex0 + Ed + W

table2: Coefficients for each model.

Model	Coefficients
Linear model	R = R = -2.310635+0.012725*Age + 0.021344*Ed + 0.012930*Ex0 + 0.009798*U2 + 0.006608*X
Quasibinomial	R1= -224.80112 +0.49310*Age+0.36407*Ex1 +0.11835*LF+-0.05242*NW+ 0.36543*U2+0.25849*X
Quasipoisson	R2= -2.967425+0.012161Age+0.015589Ed +0.009611Ex0 +0.007522U2 +0.002311W+0.009295X

table3: Frequency of significant covariates.

covariate	number of appreance
Age X	3
Ex0 Ed U2	2
Ex1 LF NW W	1

Table4: significance level of each covariate of each model. (# : Quasi)

covariate	Linear	#Bin	#Poiss
(Intercept)	.	**	*

covariate	Linear	#Bin	#Poiss
Age	*	**	*
U2	.	**	
X	***	**	***
Ex0	***		***
Ed	***		**
Ex1		***	
LF		**	
NW		**	
W			*

- Looking at Table 3 and 4, we can see 'X', The number of families per 1000 earning below 1/2 the median income, is the most significantly predictive for the crime rate. This is because the variable X is significant for all models and it's P-value is relatively smaller than other significant variables. Following X, the variable 'Age', The number of males of age 14-24 per 1000 population, is the secondly significant predictor.
- Ex0, Ed, U2 appear 2 times and their P-values are very small as long as they appear. It means economic status, Education level, and employment status(unemployment) affect on the crime rate, even though they are not crucial as the Age and X.
- We can conclude that these three types of different models lead to similar conclusions. Therefore, we are more confident about these conclusions than those based on a single model. However, there are some difference between the models one another because each model has its own assumptions which does not hold, such as dispersion parameters for logit and poisson model.
- In this case, we can say linear model fits the data the best. As we confirmed, the assumptions for the linear model hold well. On the other hand, the dispersion parameter for quasi logit model and quasi poisson model are 0.4 and 5.3, which means the assumptions do not hold well. Therefore, we conclude the linear model fits the data well.

Appendix

```r
#Read Table and omit NA.
crime.dat <- read.table("~/Library/Mobile Documents/com~apple~CloudDocs/crime.dat.txt", header = T)
crime.dat<-na.omit(crime.dat)
attach(crime.dat)


#Full model test
fit1=lm(R~.,data=crime.dat)
summary(fit1)
```

```
##
## Call:
## lm(formula = R ~ ., data = crime.dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -37.084 -13.299   1.818  13.953  48.498
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -753.94415  173.40191  -4.348 0.000164 ***
```

```
## Age            1.38771    0.58150   2.386 0.024011 *
## S             -3.77882   16.78753  -0.225 0.823539
## Ed             1.46481    0.80926   1.810 0.081030 .
## Ex0            1.13689    1.22329   0.929 0.360640
## Ex1           -0.12237    1.35167  -0.091 0.928510
## LF             0.06729    0.25164   0.267 0.791102
## M              0.15977    0.25792   0.619 0.540609
## N             -0.02862    0.14343  -0.200 0.843264
## NW            -0.02844    0.07612  -0.374 0.711450
## U1            -0.70749    0.52643  -1.344 0.189758
## U2             2.23189    0.98459   2.267 0.031319 *
## W              0.12587    0.11359   1.108 0.277217
## X              0.76347    0.27209   2.806 0.009025 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 23.14 on 28 degrees of freedom
## Multiple R-squared:  0.779,  Adjusted R-squared:  0.6764
## F-statistic: 7.592 on 13 and 28 DF,  p-value: 4.026e-06
```

```r
#Variable selection by Stepwise
fit2 <- step(fit1, direction="both")
```

```
## Start:  AIC=274.88
## R ~ Age + S + Ed + Ex0 + Ex1 + LF + M + N + NW + U1 + U2 + W +
##     X
##
##        Df Sum of Sq   RSS    AIC
## - Ex1   1       4.4 15003 272.89
## - N     1      21.3 15020 272.94
## - S     1      27.1 15026 272.95
## - LF    1      38.3 15037 272.99
## - NW    1      74.8 15074 273.09
## - M     1     205.6 15204 273.45
## - Ex0   1     462.7 15462 274.15
## - W     1     657.8 15657 274.68
## <none>              14999 274.88
## - U1    1     967.5 15966 275.50
## - Ed    1    1755.1 16754 277.53
## - U2    1    2752.5 17752 279.95
## - Age   1    3050.7 18050 280.65
## - X     1    4217.5 19216 283.29
##
## Step:  AIC=272.89
## R ~ Age + S + Ed + Ex0 + LF + M + N + NW + U1 + U2 + W + X
##
##        Df Sum of Sq   RSS    AIC
## - N     1      21.6 15025 270.95
## - S     1      24.5 15028 270.96
## - LF    1      59.3 15063 271.06
## - NW    1      88.5 15092 271.14
## - M     1     201.2 15204 271.45
## - W     1     653.8 15657 272.68
## <none>              15003 272.89
## - U1    1     964.6 15968 273.51
```

```
## + Ex1    1       4.4 14999 274.88
## - Ed     1    1892.2 16896 275.88
## - U2     1    2827.2 17830 278.14
## - Age    1    3419.3 18423 279.51
## - X      1    4216.2 19220 281.29
## - Ex0    1    8044.7 23048 288.92
##
## Step:  AIC=270.95
## R ~ Age + S + Ed + Ex0 + LF + M + NW + U1 + U2 + W + X
##
##        Df Sum of Sq   RSS    AIC
## - S     1      22.3 15047 269.01
## - LF    1      49.0 15074 269.09
## - NW    1      89.1 15114 269.20
## - M     1     359.2 15384 269.94
## - W     1     632.2 15657 270.68
## <none>              15025 270.95
## - U1    1    1080.6 16106 271.87
## + N     1      21.6 15003 272.89
## + Ex1   1       4.6 15020 272.94
## - Ed    1    1901.4 16926 273.96
## - U2    1    2851.5 17876 276.25
## - Age   1    3449.0 18474 277.63
## - X     1    4430.4 19455 279.81
## - Ex0   1    9427.3 24452 289.41
##
## Step:  AIC=269.01
## R ~ Age + Ed + Ex0 + LF + M + NW + U1 + U2 + W + X
##
##        Df Sum of Sq   RSS    AIC
## - LF    1     136.8 15184 267.39
## - NW    1     170.8 15218 267.49
## - M     1     341.1 15388 267.95
## - W     1     610.6 15658 268.68
## <none>              15047 269.01
## - U1    1    1136.0 16183 270.07
## + S     1      22.3 15025 270.95
## + N     1      19.3 15028 270.96
## + Ex1   1       2.0 15045 271.01
## - Ed    1    1898.8 16946 272.00
## - U2    1    2839.1 17886 274.27
## - Age   1    3596.6 18644 276.01
## - X     1    4912.5 19960 278.88
## - Ex0   1   10406.1 25453 289.09
##
## Step:  AIC=267.39
## R ~ Age + Ed + Ex0 + M + NW + U1 + U2 + W + X
##
##        Df Sum of Sq   RSS    AIC
## - NW    1     199.8 15384 265.94
## - W     1     622.3 15806 267.08
## <none>              15184 267.39
## - M     1     942.7 16127 267.92
## + LF    1     136.8 15047 269.01
```

```
## + S      1     110.1 15074 269.09
## + Ex1    1      35.3 15149 269.30
## + N      1       2.1 15182 269.39
## - U1     1    1604.4 16788 269.61
## - U2     1    2803.5 17988 272.51
## - Ed     1    3076.7 18261 273.14
## - Age    1    3730.2 18914 274.62
## - X      1    5696.8 20881 278.77
## - Ex0    1   10271.2 25455 287.09
##
## Step:  AIC=265.94
## R ~ Age + Ed + Ex0 + M + U1 + U2 + W + X
##
##          Df Sum of Sq   RSS    AIC
## - W      1     749.8 16134 265.94
## <none>               15384 265.94
## - M      1    1050.2 16434 266.72
## + S      1     242.2 15142 267.28
## + NW     1     199.8 15184 267.39
## + LF     1     165.8 15218 267.49
## + Ex1    1      76.1 15308 267.73
## - U1     1    1464.7 16848 267.76
## + N      1       0.8 15383 267.94
## - U2     1    2610.2 17994 270.52
## - Ed     1    3284.9 18669 272.07
## - Age    1    3554.4 18938 272.67
## - X      1    5623.6 21007 277.03
## - Ex0    1   10726.5 26110 286.16
##
## Step:  AIC=265.94
## R ~ Age + Ed + Ex0 + M + U1 + U2 + X
##
##          Df Sum of Sq   RSS    AIC
## <none>               16134 265.94
## + W      1     749.8 15384 265.94
## + NW     1     327.3 15806 267.08
## - M      1    1345.0 17479 267.31
## + S      1     206.4 15927 267.40
## + LF     1     189.8 15944 267.44
## + Ex1    1      78.0 16056 267.74
## + N      1      16.6 16117 267.90
## - U1     1    1972.7 18106 268.79
## - Age    1    3146.2 19280 271.42
## - U2     1    3400.3 19534 271.97
## - Ed     1    4161.6 20295 273.58
## - X      1    5559.9 21693 276.38
## - Ex0    1   18654.3 34788 296.21
```

```r
summary(fit2)
```

```
##
## Call:
## lm(formula = R ~ Age + Ed + Ex0 + M + U1 + U2 + X, data = crime.dat)
##
## Residuals:
```

```
##      Min       1Q   Median       3Q      Max
## -41.252 -10.029   0.014  15.006  54.445
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -713.4473   139.5666  -5.112 1.23e-05 ***
## Age            1.1238     0.4364   2.575  0.01455 *
## Ed             1.7967     0.6067   2.961  0.00555 **
## Ex0            1.0798     0.1722   6.270 3.85e-07 ***
## M              0.2662     0.1581   1.684  0.10142
## U1            -0.8218     0.4030  -2.039  0.04929 *
## U2             2.3159     0.8651   2.677  0.01135 *
## X              0.5461     0.1595   3.423  0.00163 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 21.78 on 34 degrees of freedom
## Multiple R-squared:  0.7623, Adjusted R-squared:  0.7133
## F-statistic: 15.57 on 7 and 34 DF,  p-value: 5.996e-09
```

```r
#Model selection ->fit2
anova(fit2, fit1)
```

```
## Analysis of Variance Table
##
## Model 1: R ~ Age + Ed + Ex0 + M + U1 + U2 + X
## Model 2: R ~ Age + S + Ed + Ex0 + Ex1 + LF + M + N + NW + U1 + U2 + W +
##     X
##   Res.Df   RSS Df Sum of Sq     F Pr(>F)
## 1     34 16134
## 2     28 14999  6    1134.7 0.353 0.9021
```

```r
#drop test->comparing AIC, drop M.
drop1(fit2, test="Chi")
```

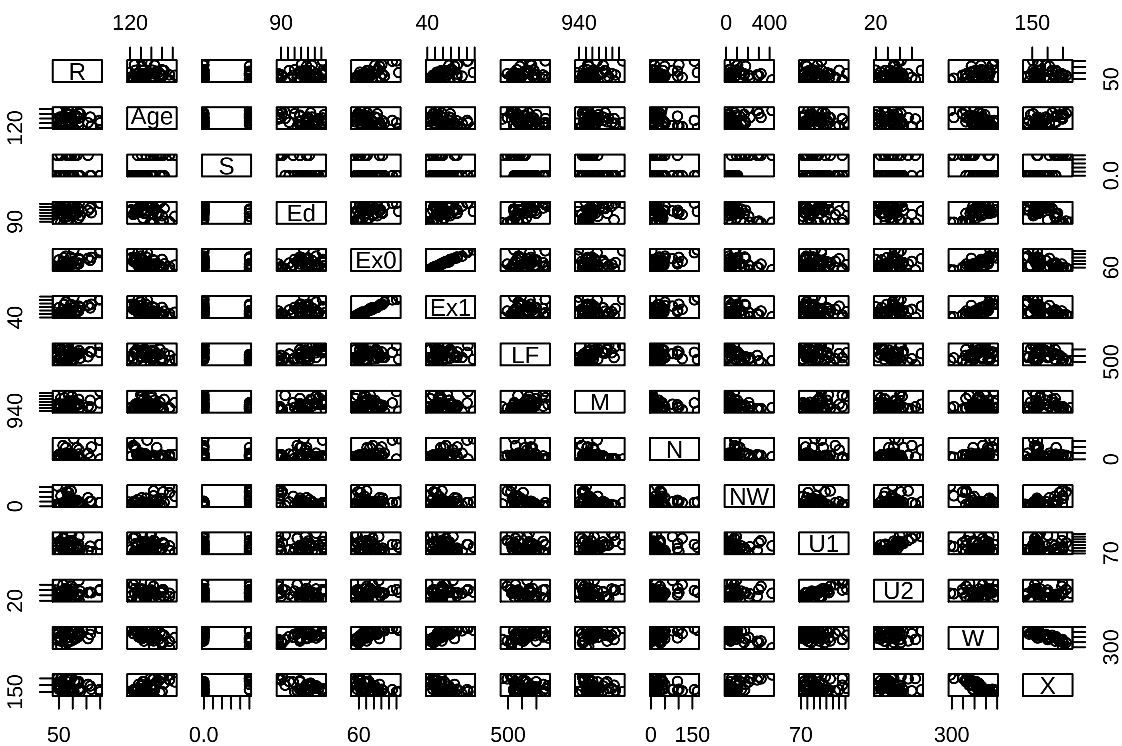
```
## Single term deletions
##
## Model:
## R ~ Age + Ed + Ex0 + M + U1 + U2 + X
##        Df Sum of Sq   RSS    AIC  Pr(>Chi)
## <none>              16134 265.94
## Age     1    3146.2 19280 271.42  0.006230 **
## Ed      1    4161.6 20295 273.58  0.001906 **
## Ex0     1   18654.3 34788 296.21 1.341e-08 ***
## M       1    1345.0 17479 267.31  0.066672 .
## U1      1    1972.7 18106 268.79  0.027726 *
## U2      1    3400.3 19534 271.97  0.004595 **
## X       1    5559.9 21693 276.38  0.000421 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fit3<-lm(R ~ Age + Ed + Ex0  + U1 + U2 + X, data=crime.dat)
summary(fit3)
```

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

```
## lm(formula = R ~ Age + Ed + Ex0 + U1 + U2 + X, data = crime.dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -50.029 -12.701    1.412   13.178   58.768
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -548.8628   102.1876  -5.371 5.21e-06 ***
## Age            1.2143     0.4443   2.733 0.009774 **
## Ed             2.2658     0.5528   4.098 0.000235 ***
## Ex0            1.1253     0.1745   6.449 1.99e-07 ***
## U1            -0.4693     0.3533  -1.328 0.192678
## U2             1.8645     0.8438   2.210 0.033774 *
## X              0.6102     0.1589   3.839 0.000496 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 22.35 on 35 degrees of freedom
## Multiple R-squared:  0.7425, Adjusted R-squared:  0.6983
## F-statistic: 16.82 on 6 and 35 DF,  p-value: 5.056e-09
```

```
#Checking correlation of two covariates.
#Check Multicollinearity by scatter plot.
#Multicollinearity searching out.
pairs(crime.dat)
```




```
cor(crime.dat)
```

```
##               R         Age           S          Ed         Ex0
## R    1.00000000 -0.06385252 -0.07019063  0.32329860  0.68928252
## Age -0.06385252  1.00000000  0.49563186 -0.39091483 -0.49264875
```

```
## S   -0.07019063  0.49563186  1.00000000 -0.64747633 -0.32045788
## Ed   0.32329860 -0.39091483 -0.64747633  1.00000000  0.43282086
## Ex0  0.68928252 -0.49264875 -0.32045788  0.43282086  1.00000000
## Ex1  0.66846426 -0.50269330 -0.32345526  0.44809353  0.99373404
## LF   0.20705534 -0.29152317 -0.58723686  0.69798059  0.15264744
## M    0.21121021  0.01526966 -0.31959407  0.46296602  0.02165309
## N    0.34127174 -0.35436566 -0.05410083 -0.01910621  0.54442047
## NW   0.05956120  0.47094928  0.76829134 -0.64603429 -0.16258262
## U1  -0.07289827 -0.08793529 -0.09174550 -0.09731568 -0.10466577
## U2   0.17420312 -0.23140870  0.10052251 -0.27269674  0.18260950
## W    0.44673029 -0.61824271 -0.57843178  0.68823067  0.77793369
## X   -0.16028052  0.59009977  0.69969529 -0.72343269 -0.60017237
##             Ex1         LF            M           N          NW
## R    0.668464257  0.2070553  0.211210205  0.34127174  0.05956120
## Age -0.502693296 -0.2915232  0.015269658 -0.35436566  0.47094928
## S   -0.323455258 -0.5872369 -0.319594067 -0.05410083  0.76829134
## Ed   0.448093527  0.6979806  0.462966021 -0.01910621 -0.64603429
## Ex0  0.993734036  0.1526474  0.021653093  0.54442047 -0.16258262
## Ex1  1.000000000  0.1377729  0.009534882  0.53579205 -0.16923348
## LF   0.137772867  1.0000000  0.565086214 -0.12012675 -0.48842912
## M    0.009534882  0.5650862  1.000000000 -0.41148463 -0.33211203
## N    0.535792054 -0.1201267 -0.411484630  1.00000000  0.10696571
## NW  -0.169233485 -0.4884291 -0.332112027  0.10696571  1.00000000
## U1  -0.114386133 -0.2457952  0.346560909 -0.03757046 -0.05142211
## U2   0.166347617 -0.4329123 -0.034433867  0.28474593  0.17986948
## W    0.786065251  0.3563029  0.171175479  0.33141816 -0.55176568
## X   -0.618469311 -0.3391087 -0.162806574 -0.13203942  0.68518986
##             U1          U2           W           X
## R   -0.07289827  0.17420312  0.44673029 -0.16028052
## Age -0.08793529 -0.23140870 -0.61824271  0.59009977
## S   -0.09174550  0.10052251 -0.57843178  0.69969529
## Ed  -0.09731568 -0.27269674  0.68823067 -0.72343269
## Ex0 -0.10466577  0.18260950  0.77793369 -0.60017237
## Ex1 -0.11438613  0.16634762  0.78606525 -0.61846931
## LF  -0.24579517 -0.43291231  0.35630295 -0.33910873
## M    0.34656091 -0.03443387  0.17117548 -0.16280657
## N   -0.03757046  0.28474593  0.33141816 -0.13203942
## NW  -0.05142211  0.17986948 -0.55176568  0.68518986
## U1   1.00000000  0.75410791 -0.04905061  0.02051815
## U2   0.75410791  1.00000000  0.07625084  0.02605951
## W   -0.04905061  0.07625084  1.00000000 -0.86974138
## X    0.02051815  0.02605951 -0.86974138  1.00000000
```

```r
#I figured out U1, U2 has corralation, so I deleted U1.
fit4<-lm(R ~ Age + Ed + Ex0  + U2 + X, data=crime.dat)
summary(fit4)
```

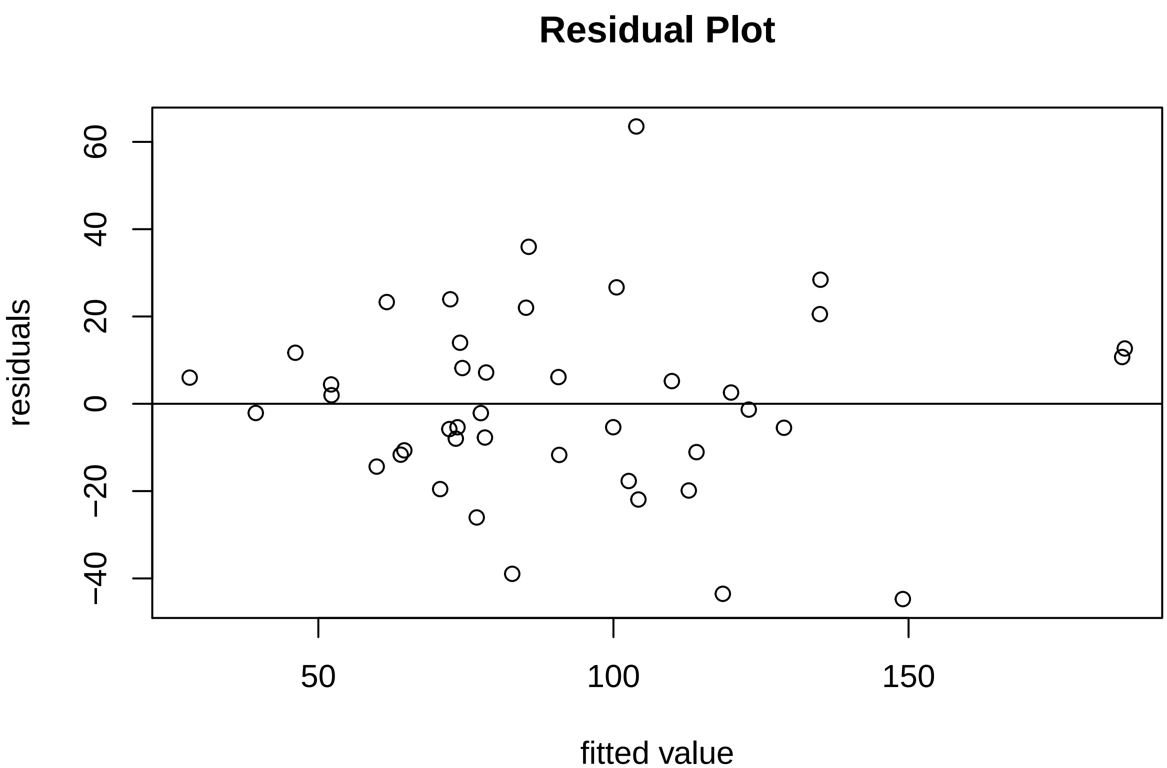
```
##
## Call:
## lm(formula = R ~ Age + Ed + Ex0 + U2 + X, data = crime.dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -44.731 -11.514  -1.714  11.447  63.525
##
```

```
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)    
## (Intercept) -536.8031   102.8584  -5.219 7.69e-06 ***
## Age            1.1338     0.4448   2.549 0.015213 *  
## Ed             2.0046     0.5221   3.839 0.000481 ***
## Ex0            1.2429     0.1519   8.181 9.91e-10 ***
## U2             0.9285     0.4692   1.979 0.055501 .  
## X              0.6277     0.1601   3.922 0.000378 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 22.58 on 36 degrees of freedom
## Multiple R-squared:  0.7295, Adjusted R-squared:  0.6919 
## F-statistic: 19.41 on 5 and 36 DF,  p-value: 2.455e-09
```

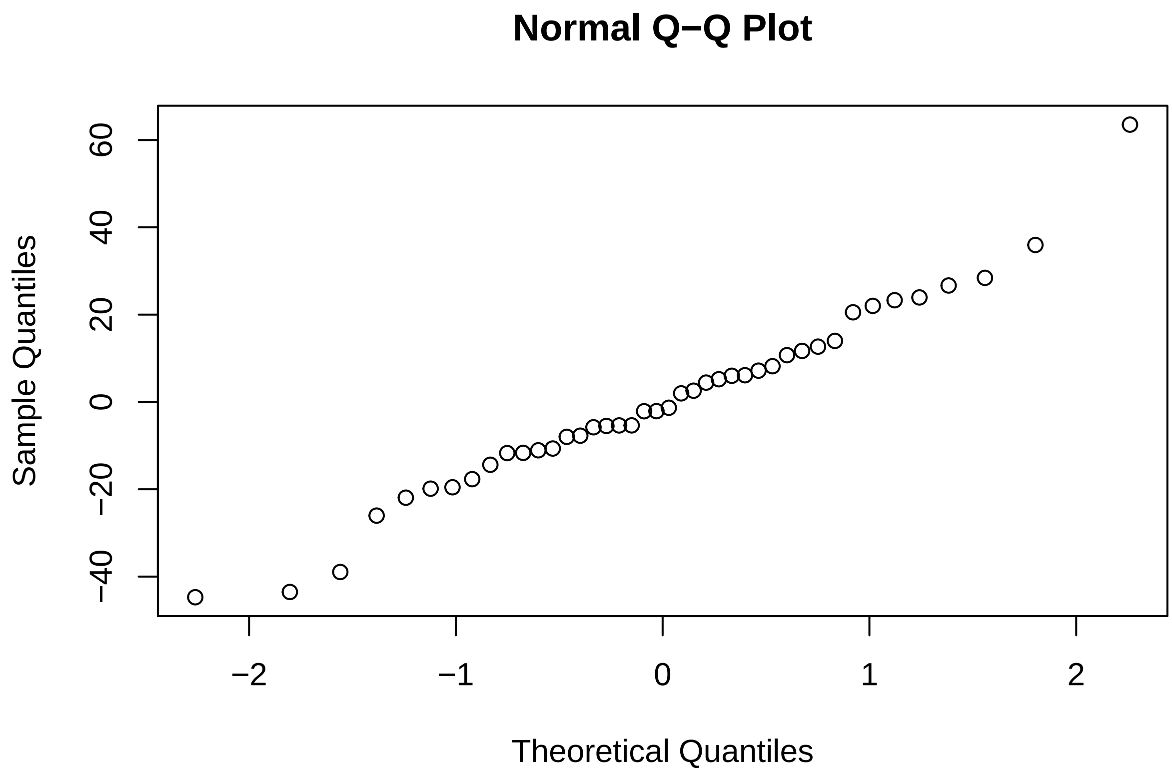
```r
#Anova test and check which model is the best.
anova(fit4,fit3)
```

```
## Analysis of Variance Table
## 
## Model 1: R ~ Age + Ed + Ex0 + U2 + X
## Model 2: R ~ Age + Ed + Ex0 + U1 + U2 + X
##   Res.Df   RSS Df Sum of Sq      F Pr(>F)
## 1     36 18360                           
## 2     35 17479  1     881.1 1.7644 0.1927
```

```r
#Residual Plot and Normal QQ Plot.
plot(fitted(fit4), resid(fit4), main="Residual Plot",
     xlab="fitted value", ylab="residuals")
abline(a=0,b=0)
```



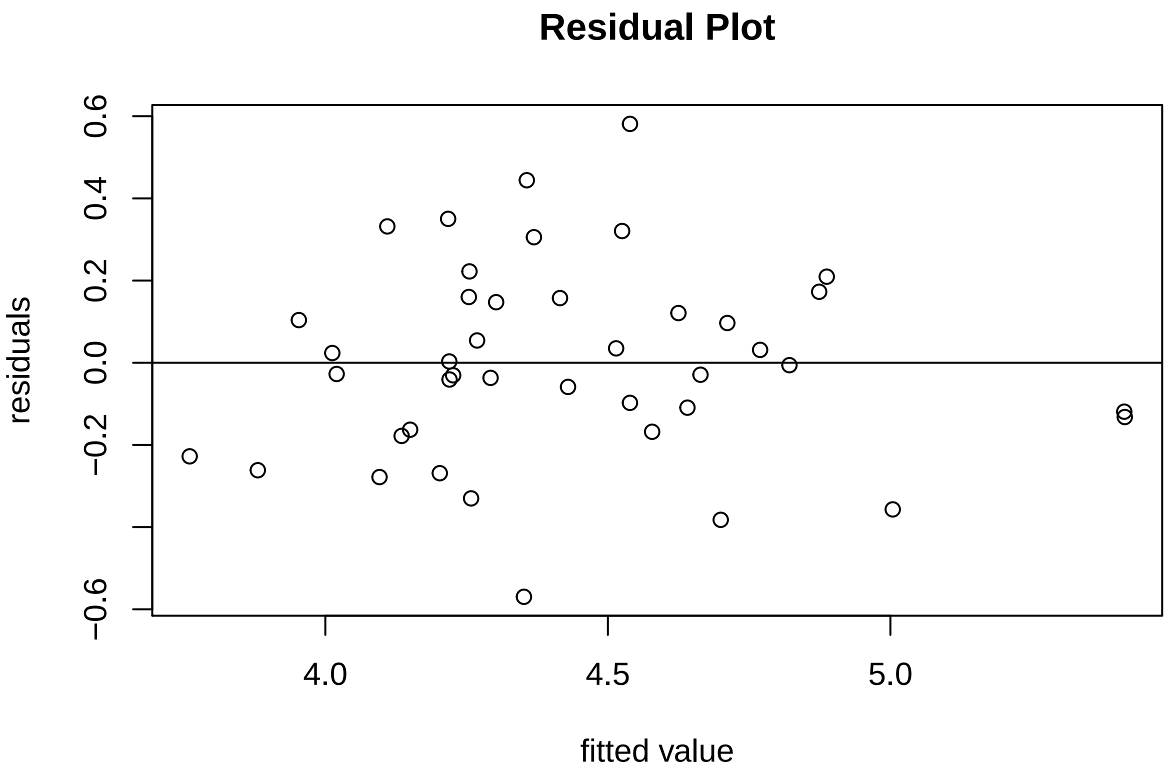
```r
qqnorm(resid(fit4))
```



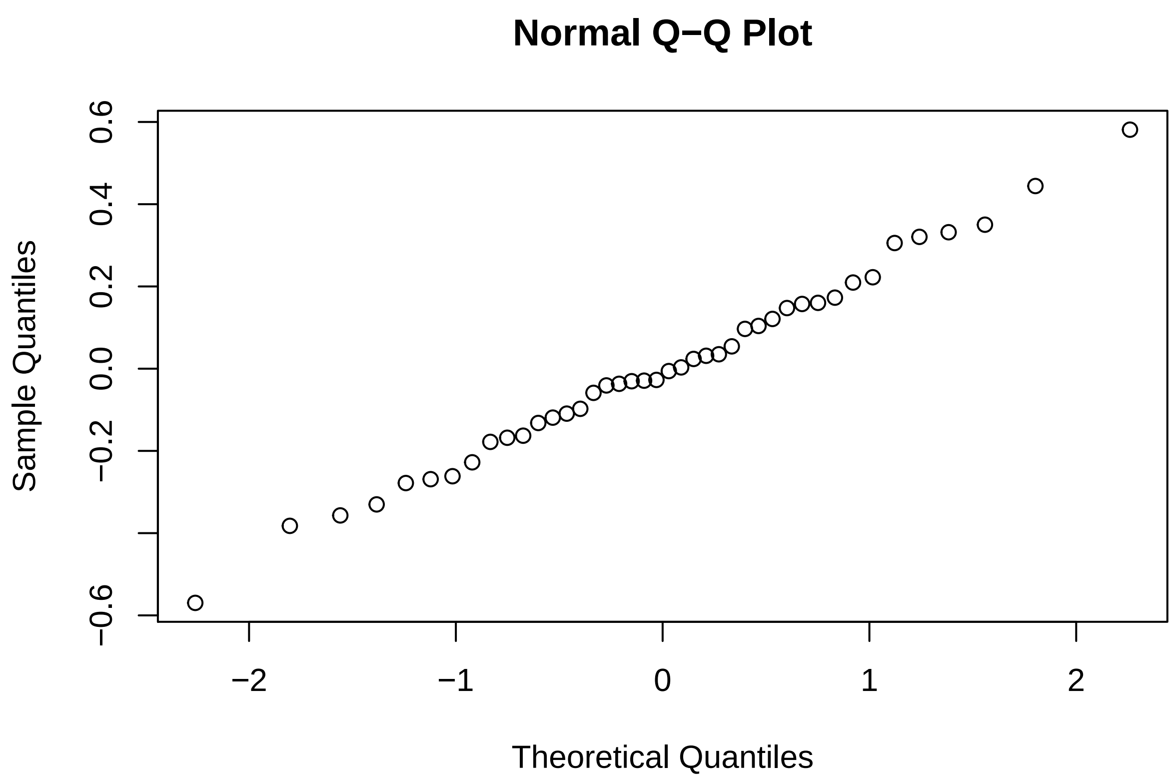

```r
# Log transformation to stabilize nonconstant variance.
fit4<-lm(log(R) ~ Age + Ed + Ex0  + U2 + X, data=crime.dat)
summary(fit4)
```

```
##
## Call:
## lm(formula = log(R) ~ Age + Ed + Ex0 + U2 + X, data = crime.dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.56958 -0.15524 -0.01662  0.15487  0.58120
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.310635   1.157462  -1.996 0.053508 .
## Age          0.012725   0.005005   2.542 0.015462 *
## Ed           0.021344   0.005876   3.633 0.000867 ***
## Ex0          0.012930   0.001710   7.563 6.08e-09 ***
## U2           0.009798   0.005280   1.856 0.071695 .
## X            0.006608   0.001801   3.669 0.000782 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2541 on 36 degrees of freedom
## Multiple R-squared:  0.6986, Adjusted R-squared:  0.6567
## F-statistic: 16.69 on 5 and 36 DF,  p-value: 1.618e-08
```

```r
plot(fitted(fit4), resid(fit4), main="Residual Plot",
     xlab="fitted value", ylab="residuals")
abline(a=0,b=0)
```




```r
qqnorm(resid(fit4))
```



```r
# It seems there is no influence point by checking cooks distance.
cooks.distance(fit4)
```

```
##            1            2            3            4            5
## 1.469253e-03 1.122841e-02 4.418245e-03 1.530801e-02 1.729170e-05
##            6            7            8            9           10
## 6.795449e-06 2.536306e-02 1.062423e-02 1.263408e-02 3.825513e-04
##           11           12           13           14           16
## 1.138008e-01 1.683962e-02 4.328750e-02 3.258476e-04 6.051160e-04
##           17           18           19           20           22
## 9.360456e-03 3.756783e-03 3.953825e-02 9.364447e-03 1.845464e-01
##           23           24           25           26           27
## 7.994543e-02 9.830452e-03 2.026034e-02 1.266108e-02 4.863364e-02
##           28           29           31           32           33
## 4.082768e-04 1.687610e-01 2.835826e-02 8.067413e-04 2.673428e-02
##           35           36           38           39           40
## 1.011021e-03 1.476792e-01 2.580152e-04 8.957792e-03 2.918426e-03
##           41           42           43           44           45
## 4.619737e-02 3.197371e-04 2.079855e-02 2.797919e-04 7.517271e-02
##           46           47
## 6.366839e-02 3.940702e-03
```

```r
which(cooks.distance(fit4)>1)
```

```
## named integer(0)
```

```r
##################################Binomial Logit model.##################

# Nonconverging logit GLM
R1<-as.numeric(R>105)
fit1_bin<-glm(R1~.-R,family=binomial,data=crime.dat)
```

```
## Warning: glm.fit: algorithm did not converge
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
summary(fit1_bin)
```

```
##
## Call:
## glm(formula = R1 ~ . - R, family = binomial, data = crime.dat)
##
## Deviance Residuals:
##        Min          1Q      Median          3Q         Max
## -2.101e-05  -2.110e-08  -2.110e-08   2.110e-08   2.163e-05
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -2.555e+03  1.826e+06  -0.001    0.999
## Age          6.172e+00  5.277e+03   0.001    0.999
## S            3.456e+01  1.171e+05   0.000    1.000
## Ed           6.155e-02  6.552e+03   0.000    1.000
## Ex0          2.021e+00  5.144e+03   0.000    1.000
## Ex1          2.714e+00  6.356e+03   0.000    1.000
## LF           2.085e+00  2.026e+03   0.001    0.999
## M           -9.660e-01  1.723e+03  -0.001    1.000
## N           -7.047e-01  1.197e+03  -0.001    1.000
```

```
## NW          -6.412e-01  6.642e+02  -0.001    0.999
## U1          -1.408e+00  2.366e+03  -0.001    1.000
## U2           7.340e+00  7.361e+03   0.001    0.999
## W            4.749e-01  8.717e+02   0.001    1.000
## X            3.812e+00  3.733e+03   0.001    0.999
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 5.0255e+01  on 41  degrees of freedom
## Residual deviance: 3.5072e-09  on 28  degrees of freedom
## AIC: 28
##
## Number of Fisher Scoring iterations: 25
```

```r
# stepwise. But still nonconverging.
fit2_bin <- step(fit1_bin, direction="both")
```

```
## Start:  AIC=28
## R1 ~ (R + Age + S + Ed + Ex0 + Ex1 + LF + M + N + NW + U1 + U2 +
##     W + X) - R

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##        Df Deviance   AIC
## - Ed    1    0.000 26.00
## - S     1    0.000 26.00
## - Ex1   1    0.000 26.00
## - Ex0   1    0.000 26.00
## - U1    1    0.000 26.00
## - N     1    0.000 26.00
## - M     1    0.000 26.00
## - W     1    0.000 26.00
## - LF    1    0.000 26.00
## - Age   1    0.000 26.00
## - U2    1    0.000 26.00
## - NW    1    0.000 26.00
## <none>       0.000 28.00
## - X     1   25.441 51.44

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##
## Step:  AIC=26
## R1 ~ Age + S + Ex0 + Ex1 + LF + M + N + NW + U1 + U2 + W + X

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
##        Df Deviance    AIC
## - S     1    0.000 24.000
## - Ex0   1    0.000 24.000
## - Ex1   1    0.000 24.000
## - U1    1    0.000 24.000
## - N     1    0.000 24.000
## - M     1    0.000 24.000
## - W     1    0.000 24.000
## <none>       0.000 26.000
## + Ed    1    0.000 28.000
## - U2    1   13.505 37.505
## - NW    1   17.414 41.414
## - LF    1   17.959 41.959
## - Age   1   20.829 44.829
## - X     1   26.403 50.403

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##
## Step:  AIC=24
## R1 ~ Age + Ex0 + Ex1 + LF + M + N + NW + U1 + U2 + W + X

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##        Df Deviance    AIC
## - Ex0   1    0.000 22.000
```

```
## - M      1    0.000 22.000
## - U1     1    0.000 22.000
## - W      1    0.000 22.000
## - Ex1    1    0.000 22.000
## - N      1    0.000 22.000
## <none>        0.000 24.000
## + S      1    0.000 26.000
## + Ed     1    0.000 26.000
## - U2     1   13.863 35.863
## - NW     1   17.794 39.794
## - LF     1   18.347 40.347
## - Age    1   20.934 42.934
## - X      1   26.578 48.577

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##
## Step:  AIC=22
## R1 ~ Age + Ex1 + LF + M + N + NW + U1 + U2 + W + X

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##        Df Deviance    AIC
## - W      1    0.000 20.000
## - U1     1    0.000 20.000
## - N      1    0.000 20.000
## - M      1    0.000 20.000
## <none>        0.000 22.000
## + Ex0    1    0.000 24.000
## + Ed     1    0.000 24.000
## + S      1    0.000 24.000
```

```
## - U2    1   18.999 38.999
## - NW    1   19.629 39.629
## - LF    1   20.247 40.247
## - Age   1   23.575 43.575
## - X     1   28.012 48.012
## - Ex1   1   31.657 51.657
```

```
## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##
## Step:  AIC=20
## R1 ~ Age + Ex1 + LF + M + N + NW + U1 + U2 + X

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
##        Df Deviance    AIC
## - N     1    0.000 18.000
## - U1    1    0.000 18.000
## - M     1    0.000 18.000
## <none>       0.000 20.000
## + W     1    0.000 22.000
## + Ex0   1    0.000 22.000
## + S     1    0.000 22.000
## + Ed    1    0.000 22.000
## - U2    1   21.012 39.012
## - NW    1   21.080 39.080
## - LF    1   22.134 40.134
## - Age   1   24.510 42.510
## - X     1   31.681 49.681
## - Ex1   1   36.398 54.398
```

```
## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##
## Step:  AIC=18
## R1 ~ Age + Ex1 + LF + M + NW + U1 + U2 + X

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##        Df Deviance    AIC
## - M     1    0.000 16.000
## <none>       0.000 18.000
## + N     1    0.000 20.000
## + Ed    1    0.000 20.000
## + Ex0   1    0.000 20.000
## + S     1    0.000 20.000
## + W     1    0.000 20.000
## - U1    1    9.467 25.467
## - U2    1   21.705 37.705
## - NW    1   22.093 38.093
## - LF    1   22.569 38.569
## - Age   1   27.130 43.130
## - X     1   31.872 47.872
## - Ex1   1   39.914 55.914

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##
## Step:  AIC=16
## R1 ~ Age + Ex1 + LF + NW + U1 + U2 + X
```

```
## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##        Df Deviance    AIC
## <none>       0.000 16.000
## + M     1    0.000 18.000
## + Ex0   1    0.000 18.000
## + S     1    0.000 18.000
## + W     1    0.000 18.000
## + Ed    1    0.000 18.000
## + N     1    0.000 18.000
## - U1    1   14.925 28.925
## - U2    1   22.827 36.827
## - NW    1   23.203 37.203
## - LF    1   26.015 40.015
## - Age   1   28.406 42.406
## - X     1   32.277 46.277
## - Ex1   1   40.340 54.340
```

```r
summary(fit2_bin)
```

```
##
## Call:
## glm(formula = R1 ~ Age + Ex1 + LF + NW + U1 + U2 + X, family = binomial,
##     data = crime.dat)
##
## Deviance Residuals:
##        Min          1Q      Median          3Q         Max
## -1.624e-04  -2.100e-08  -2.100e-08   2.100e-08   1.497e-04
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -2.981e+04  4.173e+06  -0.007    0.994
## Age          6.292e+01  8.893e+03   0.007    0.994
## Ex1          4.703e+01  6.593e+03   0.007    0.994
## LF           1.703e+01  2.376e+03   0.007    0.994
```

```
## NW          -7.794e+00  1.128e+03  -0.007    0.994
## U1          -1.681e+01  2.434e+03  -0.007    0.994
## U2           7.053e+01  9.971e+03   0.007    0.994
## X            3.730e+01  5.235e+03   0.007    0.994
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 5.0255e+01  on 41  degrees of freedom
## Residual deviance: 1.1303e-07  on 34  degrees of freedom
## AIC: 16
##
## Number of Fisher Scoring iterations: 25
```

```r
#Comparing AIC by drop1
drop1(fit2_bin, test = "Chisq")
```

```
## Single term deletions
##
## Model:
## R1 ~ Age + Ex1 + LF + NW + U1 + U2 + X
##        Df Deviance    AIC    LRT  Pr(>Chi)
## <none>       0.000 16.000
## Age     1   28.406 42.406 28.406 9.837e-08 ***
## Ex1     1   40.340 54.340 40.340 2.134e-10 ***
## LF      1   26.015 40.015 26.015 3.387e-07 ***
## NW      1   23.203 37.203 23.203 1.458e-06 ***
## U1      1   14.925 28.925 14.925 0.0001119 ***
## U2      1   22.827 36.827 22.827 1.772e-06 ***
## X       1   32.277 46.277 32.277 1.337e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#deleting U1 increase smallest AIC and cure multicollinearity between U1 and U2.
fit3_bin<-glm(R1 ~ Age + Ex1 + LF + NW + U2 + X,family=binomial,data=crime.dat)
summary(fit3_bin)
```

```
##
## Call:
## glm(formula = R1 ~ Age + Ex1 + LF + NW + U2 + X, family = binomial,
##     data = crime.dat)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.61813  -0.17334  -0.00911   0.00064   1.89104
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -224.80112   99.85226  -2.251   0.0244 *
## Age            0.49310    0.23287   2.117   0.0342 *
## Ex1            0.36407    0.15493   2.350   0.0188 *
## LF             0.11835    0.05567   2.126   0.0335 *
## NW            -0.05242    0.02409  -2.175   0.0296 *
## U2             0.36543    0.18594   1.965   0.0494 *
## X              0.25849    0.11386   2.270   0.0232 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 50.255  on 41  degrees of freedom
## Residual deviance: 14.925  on 35  degrees of freedom
## AIC: 28.925
##
## Number of Fisher Scoring iterations: 8
```

```
#Comparing AIC-> it seems if we drop one more covariate, AIC increase too much.
drop1(fit3_bin)# we keep this model.
```

```
## Single term deletions
##
## Model:
## R1 ~ Age + Ex1 + LF + NW + U2 + X
##        Df Deviance    AIC
## <none>      14.925 28.925
## Age     1   28.799 40.799
## Ex1     1   46.596 58.596
## LF      1   26.545 38.545
## NW      1   25.430 37.430
## U2      1   23.604 35.604
## X       1   34.369 46.369
```

```
which(cooks.distance(fit3_bin)>1)
```

```
## 29 36
## 27 32
```

```
#we check the dispersion parameter, By using quasibinomial.
fit4_bin_quasi<-glm(R1 ~ Age + Ex1 + LF + NW + U2 + X,family=quasibinomial,data=crime.dat)
summary(fit4_bin_quasi)#As quasibinimial's dispersion parameter is 0.4, we should use quasibinomial.
```

```
##
## Call:
## glm(formula = R1 ~ Age + Ex1 + LF + NW + U2 + X, family = quasibinomial,
##     data = crime.dat)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.61813  -0.17334  -0.00911   0.00064   1.89104
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -224.80112   63.60497  -3.534  0.00117 **
## Age            0.49310    0.14834   3.324  0.00209 **
## Ex1            0.36407    0.09869   3.689  0.00076 ***
## LF             0.11835    0.03546   3.338  0.00201 **
## NW            -0.05242    0.01535  -3.415  0.00163 **
## U2             0.36543    0.11844   3.085  0.00396 **
## X              0.25849    0.07253   3.564  0.00108 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for quasibinomial family taken to be 0.4057573)
```

```
##
##     Null deviance: 50.255  on 41  degrees of freedom
## Residual deviance: 14.925  on 35  degrees of freedom
## AIC: NA
##
## Number of Fisher Scoring iterations: 8
```

```r
# we cannot say the assumptions for logit model hold well.

# It seems there some influence points by checking cooks distance. As there are more than 4, we regard
cooks.distance(fit4_bin_quasi)
```

```
##            1            2            3            4            5
## 5.532683e-03 2.042198e-06 5.323739e-09 1.128879e-12 2.258090e-02
##            6            7            8            9           10
## 1.045516e-14 2.629471e-18 1.956729e-01 2.620058e-02 4.612444e-03
##           11           12           13           14           16
## 1.037216e+00 2.277876e-08 1.121336e-03 8.913233e-08 1.447586e-03
##           17           18           19           20           22
## 1.804167e-10 5.962644e-06 3.028836e-04 4.983574e-01 6.404031e-08
##           23           24           25           26           27
## 6.621986e-03 5.099907e-06 3.916894e-06 5.193960e-14 1.463504e-20
##           28           29           31           32           33
## 2.991610e-06 7.016697e+00 1.426091e-06 3.605931e-09 1.362818e-01
##           35           36           38           39           40
## 1.218351e-12 3.471215e+00 1.025251e-04 4.606454e-02 1.293005e-03
##           41           42           43           44           45
## 5.100727e-11 1.152671e-13 3.151436e-01 3.192873e-02 1.932307e-02
##           46           47
## 4.807947e-04 1.780308e+00
```

```r
which(cooks.distance(fit4_bin_quasi)>1)
```

```
## 11 29 36 47
## 11 27 32 42
```

```r
#
#################Poisson#################
# Change response variable.
R2<-round(R,digits=0)

#Full model-> many insignificant covariates exist.
fit1_poi<-glm(R2~.-R,family=poisson,data=crime.dat)
summary(fit1_poi)
```

```
##
## Call:
## glm(formula = R2 ~ . - R, family = poisson, data = crime.dat)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.7355  -1.2341   0.0658   1.1255   4.3997
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -3.0141649  0.7310482  -4.123 3.74e-05 ***
```

```
## Age          0.0156173  0.0026862   5.814 6.11e-09 ***
## S            0.0253864  0.0753745   0.337   0.7363
## Ed           0.0155140  0.0038996   3.978 6.94e-05 ***
## Ex0          0.0076323  0.0053997   1.413   0.1575
## Ex1          0.0025791  0.0061120   0.422   0.6730
## LF           0.0020777  0.0011782   1.763   0.0778 .
## M           -0.0015422  0.0012046  -1.280   0.2005
## N           -0.0010813  0.0005883  -1.838   0.0660 .
## NW          -0.0003319  0.0003683  -0.901   0.3674
## U1          -0.0053533  0.0023458  -2.282   0.0225 *
## U2           0.0219713  0.0043048   5.104 3.33e-07 ***
## W            0.0021971  0.0005283   4.159 3.20e-05 ***
## X            0.0094817  0.0012779   7.420 1.17e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 696.75  on 41  degrees of freedom
## Residual deviance: 159.16  on 28  degrees of freedom
## AIC: 450.41
##
## Number of Fisher Scoring iterations: 4
```

```
# stepwise method for variable selection.
fit2_poi <- step(fit1_poi, direction="both")
```

```
## Start:  AIC=450.41
## R2 ~ (R + Age + S + Ed + Ex0 + Ex1 + LF + M + N + NW + U1 + U2 +
##     W + X) - R
##
##        Df Deviance    AIC
## - S     1   159.28 448.52
## - Ex1   1   159.34 448.58
## - NW    1   159.98 449.22
## - M     1   160.81 450.05
## <none>      159.16 450.41
## - Ex0   1   161.17 450.42
## - LF    1   162.27 451.51
## - N     1   162.56 451.80
## - U1    1   164.38 453.63
## - Ed    1   175.11 464.35
## - W     1   176.56 465.80
## - U2    1   185.57 474.81
## - Age   1   192.86 482.11
## - X     1   213.26 502.50
##
## Step:  AIC=448.52
## R2 ~ Age + Ed + Ex0 + Ex1 + LF + M + N + NW + U1 + U2 + W + X
##
##        Df Deviance    AIC
## - Ex1   1   159.41 446.66
## - NW    1   159.99 447.23
## - M     1   160.82 448.06
## <none>      159.28 448.52
```

```
## - Ex0   1   161.42 448.66
## - N     1   162.69 449.93
## - LF    1   162.95 450.19
## + S     1   159.16 450.41
## - U1    1   166.27 453.51
## - Ed    1   176.82 464.06
## - W     1   177.08 464.32
## - U2    1   186.41 473.66
## - Age   1   194.05 481.29
## - X     1   219.81 507.05
##
## Step:  AIC=446.66
## R2 ~ Age + Ed + Ex0 + LF + M + N + NW + U1 + U2 + W + X
##
##        Df Deviance    AIC
## - NW    1   160.04 445.28
## - M     1   160.97 446.21
## <none>      159.41 446.66
## - N     1   162.74 447.98
## - LF    1   163.10 448.34
## + Ex1   1   159.28 448.52
## + S     1   159.34 448.58
## - U1    1   166.53 451.78
## - W     1   177.60 462.85
## - Ed    1   181.28 466.52
## - U2    1   186.47 471.71
## - Age   1   195.30 480.54
## - X     1   219.90 505.14
## - Ex0   1   237.62 522.87
##
## Step:  AIC=445.28
## R2 ~ Age + Ed + Ex0 + LF + M + N + U1 + U2 + W + X
##
##        Df Deviance    AIC
## - M     1   161.60 444.85
## <none>      160.04 445.28
## - N     1   163.29 446.53
## + NW    1   159.41 446.66
## + Ex1   1   159.99 447.23
## + S     1   160.02 447.27
## - LF    1   164.12 447.37
## - U1    1   166.64 449.88
## - W     1   179.38 462.63
## - Ed    1   182.88 466.12
## - U2    1   186.69 469.94
## - Age   1   195.49 478.73
## - X     1   224.55 507.79
## - Ex0   1   242.05 525.29
##
## Step:  AIC=444.85
## R2 ~ Age + Ed + Ex0 + LF + N + U1 + U2 + W + X
##
##        Df Deviance    AIC
## - N     1   163.33 444.58
```

```
## <none>      161.60 444.85
## + M     1   160.04 445.28
## - LF    1   164.12 445.37
## + NW    1   160.97 446.21
## + S     1   161.36 446.61
## + Ex1   1   161.54 446.79
## - U1    1   176.47 457.71
## - W     1   179.57 460.82
## - Ed    1   183.56 464.80
## - U2    1   189.65 470.89
## - Age   1   196.54 477.78
## - X     1   225.85 507.09
## - Ex0   1   249.40 530.64
##
## Step:  AIC=444.58
## R2 ~ Age + Ed + Ex0 + LF + U1 + U2 + W + X
##
##        Df Deviance    AIC
## <none>      163.33 444.58
## + N     1   161.60 444.85
## + NW    1   162.78 446.02
## + M     1   163.29 446.53
## + S     1   163.32 446.56
## + Ex1   1   163.32 446.57
## - LF    1   167.61 446.85
## - U1    1   177.63 456.87
## - W     1   179.72 458.96
## - Ed    1   184.55 463.79
## - U2    1   191.44 470.68
## - Age   1   206.25 485.50
## - X     1   228.35 507.60
## - Ex0   1   251.31 530.55
```

```r
summary(fit2_poi)#formula = R2 ~ Age + Ed + Ex0 + LF + U1 + U2 + W + X
```

```
##
## Call:
## glm(formula = R2 ~ Age + Ed + Ex0 + LF + U1 + U2 + W + X, family = poisson,
##     data = crime.dat)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.4850  -1.3918   0.0021   1.1219   4.1006
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -3.5084194  0.5675745  -6.181 6.35e-10 ***
## Age          0.0144503  0.0021869   6.608 3.91e-11 ***
## Ed           0.0159117  0.0034594   4.600 4.23e-06 ***
## Ex0          0.0086052  0.0009136   9.419  < 2e-16 ***
## LF           0.0013713  0.0006634   2.067 0.038739 *
## U1          -0.0066845  0.0017783  -3.759 0.000171 ***
## U2           0.0217280  0.0041314   5.259 1.45e-07 ***
## W            0.0020099  0.0004985   4.032 5.53e-05 ***
## X            0.0083884  0.0010567   7.939 2.05e-15 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 696.75  on 41  degrees of freedom
## Residual deviance: 163.33  on 33  degrees of freedom
## AIC: 444.58
##
## Number of Fisher Scoring iterations: 4
```

```r
drop1(fit2_poi)#AIC comparing- dropping LF increase very small amount of AIC.
```

```
## Single term deletions
##
## Model:
## R2 ~ Age + Ed + Ex0 + LF + U1 + U2 + W + X
##        Df Deviance    AIC
## <none>      163.33 444.58
## Age     1   206.25 485.50
## Ed      1   184.55 463.79
## Ex0     1   251.31 530.55
## LF      1   167.61 446.85
## U1      1   177.63 456.87
## U2      1   191.44 470.68
## W       1   179.72 458.96
## X       1   228.35 507.60
```

```r
#smaller model without LF, as the fit3 model.
fit3_poi<-glm(R2 ~ Age + Ed + Ex0 + U1 + U2 + W + X,family=poisson,data=crime.dat)
summary(fit3_poi)
```

```
##
## Call:
## glm(formula = R2 ~ Age + Ed + Ex0 + U1 + U2 + W + X, family = poisson,
##     data = crime.dat)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.6629  -1.6059  -0.1006   1.3050   4.3640
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -3.1501881  0.5371649  -5.864 4.51e-09 ***
## Age          0.0132097  0.0021080   6.266 3.70e-10 ***
## Ed           0.0202276  0.0027580   7.334 2.23e-13 ***
## Ex0          0.0083517  0.0008991   9.289  < 2e-16 ***
## U1          -0.0067829  0.0017716  -3.829 0.000129 ***
## U2           0.0206477  0.0040942   5.043 4.58e-07 ***
## W            0.0021321  0.0004913   4.340 1.43e-05 ***
## X            0.0090396  0.0010070   8.977  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
```

```
##
##     Null deviance: 696.75  on 41  degrees of freedom
## Residual deviance: 167.61  on 34  degrees of freedom
## AIC: 446.85
##
## Number of Fisher Scoring iterations: 4
```

```r
#ANOVA test of fit3_poi and fit2_poi
anova(fit3_poi,fit2_poi)# 4.2712 is the Deviance.
```

```
## Analysis of Deviance Table
##
## Model 1: R2 ~ Age + Ed + Ex0 + U1 + U2 + W + X
## Model 2: R2 ~ Age + Ed + Ex0 + LF + U1 + U2 + W + X
##   Resid. Df Resid. Dev Df Deviance
## 1        34     167.61
## 2        33     163.33  1   4.2712
```

```r
qchisq(0.95,1)  # qualtile of chisq is 3.84. 4.27>3.84.
```

```
## [1] 3.841459
```

```r
#So we reject the null hypothesis. we accept the model without LF.
drop1(fit3_poi)
```

```
## Single term deletions
##
## Model:
## R2 ~ Age + Ed + Ex0 + U1 + U2 + W + X
##        Df Deviance    AIC
## <none>      167.61 446.85
## Age     1   206.32 483.57
## Ed      1   221.85 499.10
## Ex0     1   252.57 529.81
## U1      1   182.44 459.69
## U2      1   193.42 470.66
## W       1   186.66 463.91
## X       1   252.02 529.26
```

```r
fit4_poi<-glm(R2 ~ Age + Ed + Ex0 + U2 + W + X,family=poisson,data=crime.dat)
summary(fit4_poi) # tried a model without U1, as U1 increase AIC a little and has multicollinearity wit
```

```
##
## Call:
## glm(formula = R2 ~ Age + Ed + Ex0 + U2 + W + X, family = poisson,
##     data = crime.dat)
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
## -3.517  -1.574  -0.409   1.207   5.028
##
## Coefficients:
##                Estimate Std. Error z value Pr(>|z|)
## (Intercept) -2.9674251  0.5295779  -5.603 2.10e-08 ***
## Age          0.0121605  0.0021131   5.755 8.67e-09 ***
## Ed           0.0155893  0.0024813   6.283 3.33e-10 ***
## Ex0          0.0096107  0.0008400  11.441  < 2e-16 ***
```

```
## U2          0.0075216  0.0022144   3.397 0.000682 ***
## W           0.0023109  0.0004942   4.676 2.93e-06 ***
## X           0.0092949  0.0010098   9.205  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 696.75  on 41  degrees of freedom
## Residual deviance: 182.44  on 35  degrees of freedom
## AIC: 459.69
##
## Number of Fisher Scoring iterations: 4
```

```r
drop1(fit4_poi)
```

```
## Single term deletions
##
## Model:
## R2 ~ Age + Ed + Ex0 + U2 + W + X
##        Df Deviance    AIC
## <none>      182.44 459.69
## Age     1   215.27 490.52
## Ed      1   222.31 497.56
## Ex0     1   309.52 584.76
## U2      1   193.91 469.16
## W       1   204.54 479.78
## X       1   271.16 546.41
```

```r
anova(fit4_poi,fit3_poi)
```

```
## Analysis of Deviance Table
##
## Model 1: R2 ~ Age + Ed + Ex0 + U2 + W + X
## Model 2: R2 ~ Age + Ed + Ex0 + U1 + U2 + W + X
##   Resid. Df Resid. Dev Df Deviance
## 1        35     182.44
## 2        34     167.61  1   14.838
```

```r
qchisq(0.95,1)  # qualtile of chisq is 3.84. 14.8>3.84. So we reject the null. we accept the model
```

```
## [1] 3.841459
```

```r
# without U1. we choose fit4_poi.


#Model diagnose:dispersion parameter
fit4_poi_quasi<-glm(R2 ~ Age + Ed + Ex0+ U2+W + X,family=quasipoisson,data=crime.dat)
summary(fit4_poi_quasi)#Dispersion parameter for quasipoisson family taken to be 5.304443.
```

```
##
## Call:
## glm(formula = R2 ~ Age + Ed + Ex0 + U2 + W + X, family = quasipoisson,
##     data = crime.dat)
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
```

```
## -3.517  -1.574  -0.409   1.207   5.028
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.967425   1.219691  -2.433 0.020227 *
## Age          0.012161   0.004867   2.499 0.017310 *
## Ed           0.015589   0.005715   2.728 0.009898 **
## Ex0          0.009611   0.001935   4.968 1.77e-05 ***
## U2           0.007522   0.005100   1.475 0.149207
## W            0.002311   0.001138   2.030 0.049986 *
## X            0.009295   0.002326   3.997 0.000315 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for quasipoisson family taken to be 5.304443)
##
##     Null deviance: 696.75  on 41  degrees of freedom
## Residual deviance: 182.44  on 35  degrees of freedom
## AIC: NA
##
## Number of Fisher Scoring iterations: 4
```

```r
#We cannot say that the assumptions for Poisson model hold well.

# It seems there is no influence point by checking cooks distance.
cooks.distance(fit4_poi_quasi)
```

```
##            1            2            3            4            5
## 5.607916e-03 2.092952e-02 8.355758e-03 6.446133e-02 6.393130e-04
##            6            7            8            9           10
## 6.826866e-03 1.401040e-02 2.911889e-01 2.968060e-03 9.913456e-05
##           11           12           13           14           16
## 2.550304e-01 7.694710e-03 3.321231e-02 2.052558e-03 3.900605e-05
##           17           18           19           20           22
## 1.044094e-03 1.727563e-02 2.803781e-02 5.651241e-03 9.417397e-02
##           23           24           25           26           27
## 6.722239e-02 1.503405e-02 9.177843e-03 4.317772e-03 1.155282e-02
##           28           29           31           32           33
## 3.751006e-03 2.055620e-01 9.356117e-03 1.062677e-03 1.603135e-02
##           35           36           38           39           40
## 6.068819e-04 3.825622e-01 5.227394e-06 3.122543e-03 1.059203e-03
##           41           42           43           44           45
## 2.922631e-02 5.183314e-05 9.384296e-02 2.350365e-03 1.316548e-01
##           46           47
## 4.922729e-02 1.835852e-03
```

```r
which(cooks.distance(fit4_poi_quasi)>1)
```

```
## named integer(0)
```

```r
#For linear model R ~ Age + Ed + Ex0  + U2 + X,
#QuasibinomialR1 ~ Age + Ex1 + LF + NW + U2 + X,
#Quasipoisson R2 ~ Age + Ed + Ex0 +U2 + W + X

summary(fit4)
```

```
##
## Call:
## lm(formula = log(R) ~ Age + Ed + Ex0 + U2 + X, data = crime.dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.56958 -0.15524 -0.01662  0.15487  0.58120
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.310635   1.157462  -1.996 0.053508 .
## Age          0.012725   0.005005   2.542 0.015462 *
## Ed           0.021344   0.005876   3.633 0.000867 ***
## Ex0          0.012930   0.001710   7.563 6.08e-09 ***
## U2           0.009798   0.005280   1.856 0.071695 .
## X            0.006608   0.001801   3.669 0.000782 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2541 on 36 degrees of freedom
## Multiple R-squared:  0.6986, Adjusted R-squared:  0.6567
## F-statistic: 16.69 on 5 and 36 DF,  p-value: 1.618e-08
```

```r
summary(fit4_bin_quasi)
```

```
##
## Call:
## glm(formula = R1 ~ Age + Ex1 + LF + NW + U2 + X, family = quasibinomial,
##     data = crime.dat)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.61813  -0.17334  -0.00911   0.00064   1.89104
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -224.80112   63.60497  -3.534  0.00117 **
## Age            0.49310    0.14834   3.324  0.00209 **
## Ex1            0.36407    0.09869   3.689  0.00076 ***
## LF             0.11835    0.03546   3.338  0.00201 **
## NW            -0.05242    0.01535  -3.415  0.00163 **
## U2             0.36543    0.11844   3.085  0.00396 **
## X              0.25849    0.07253   3.564  0.00108 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for quasibinomial family taken to be 0.4057573)
##
##     Null deviance: 50.255  on 41  degrees of freedom
## Residual deviance: 14.925  on 35  degrees of freedom
## AIC: NA
##
## Number of Fisher Scoring iterations: 8
```

```r
summary(fit4_poi_quasi)
```

```
##
## Call:
## glm(formula = R2 ~ Age + Ed + Ex0 + U2 + W + X, family = quasipoisson,
##     data = crime.dat)
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
## -3.517  -1.574  -0.409   1.207   5.028
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.967425   1.219691  -2.433 0.020227 *
## Age          0.012161   0.004867   2.499 0.017310 *
## Ed           0.015589   0.005715   2.728 0.009898 **
## Ex0          0.009611   0.001935   4.968 1.77e-05 ***
## U2           0.007522   0.005100   1.475 0.149207
## W            0.002311   0.001138   2.030 0.049986 *
## X            0.009295   0.002326   3.997 0.000315 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for quasipoisson family taken to be 5.304443)
##
##     Null deviance: 696.75  on 41  degrees of freedom
## Residual deviance: 182.44  on 35  degrees of freedom
## AIC: NA
##
## Number of Fisher Scoring iterations: 4
```