Contents

1 Análise de Regressão Linear Múltipla, Conjuntos de Dados

1.1 Expectativa de Vida por País (normal)

- **Modelar a variável expectativa de vida**

1.1.1 Sobre o `Conjunto`

- Dados de todos países, derivados da OMS.

    - Dados:
        * Country: país,
        * Year: ano correspondente aos dados,
        * Status: estado da industrialização,
        * Life expectancy: expectativa de vida,
        * Adult Mortality $15 <$ idade < 60: mortalidade adulta por mil habitantes,
        * Infant deaths: mortalidade infantil por mil habitantes,
        * Alcohol: uso de álcool por litro puro (+15 anos),
        * Percentage expenditure: gasto em saúde em percentagem do PIB per capta,
        * Hepatitis B: percentagem de imunização entre bebês com um ano,
        * Measles: quantidade de casos reportados de Rubeola por mil habitantes,
        * BMI: média de index de massa corpórea da população,
        * under-five deaths: quantidade de mortes antes dos cinco anos por mil habitantes,
        * Polio: quantidade de imunização entre bebês com um ano (percentagem),
        * Total expenditure: percentagem do gasto total do governo com saúde,
        * Diphtheria: percentagem de imunização de tétano ($\leq$ 1ano),
        * HIV/AIDS: morte a cada mil nascimentos (contanto nascimento de 0-4 anos de idade),
        * GDP: PIB em dólares,
        * Population: População,

* thinness 1-19 years: prevalescência de pessoas magras (1-19 anos de idade),

* thinness 5-9 years: prevalescência de pessoas magras (5-9 anos de idade),

* Income composition of resources: IDH (qualidade de vida) em termos de composição por salário pessoal (provida por salário próprio),

* Schooling: média do número de anos sendo educado (escolaridade).

1.1.2 Como utilizar o conjunto (cópia de arquivo CSV, localmente)

O `conjunto` apenas está disponível por meio da cópia da núvem, para o computador local. Após baixar o arquivo Life_Expectancy_Data.csv, para seu computador, a análise deve ser feita, em relação a um determinado ano, a qual foi indicado ao grupo.

Por exemplo, para a análise da expectativa de vida, para o ano de 2015, seria feita invocamos os dados da seguinte maneira,

```
life <- read.csv('./data/csv/Life_Expectancy_Data.csv')
life_2015 <- subset(life, Year=="2015")
life_2015[1:6,1:5]
```

```
   Country              Year Status     Life.expectancy Adult.Mortality
1  Afghanistan          2015 Developing 65.0            263
17 Albania              2015 Developing 77.8             74
33 Algeria              2015 Developing 75.6             19
49 Angola               2015 Developing 52.4            335
65 Antigua and Barbuda  2015 Developing 76.4             13
81 Argentina            2015 Developing 76.3            116
```

Obs: apenas 5 colunas foram selecionadas, por motivos estéticos na formatação.

1.1.3 Regressão e Teste de Shapiro (normal)

1. Retirar valores do nome dos países e o ano.

```
life_2015_clean <- subset(life_2015, select=-c(Country, Year))
## life_2015_clean <- na.omit(life_2015_clean)
```

2. Transformar a variável categórica **Status** em numérica Em que teremos:

   - Developed: 1
   - Developing: 2

```
life_2015_clean$Status <- as.numeric(as.factor(life_2015_clean$Status))
## life_2015_clean <- na.omit(life_2015_clean) ## eliminando muitos dados.
summary(life_2015_clean)
```

```
    Status       Life.expectancy Adult.Mortality infant.deaths
 Min.   :1.000   Min.   :51.00   Min.   :  1.0   Min.   :  0.0
 1st Qu.:2.000   1st Qu.:65.75   1st Qu.: 74.0   1st Qu.:  0.0
 Median :2.000   Median :73.90   Median :138.0   Median :  2.0
 Mean   :1.825   Mean   :71.62   Mean   :152.9   Mean   : 23.8
 3rd Qu.:2.000   3rd Qu.:76.95   3rd Qu.:213.0   3rd Qu.: 17.0
 Max.   :2.000   Max.   :88.00   Max.   :484.0   Max.   :910.0

    Alcohol       percentage.expenditure  Hepatitis.B       Measles
 Min.   : 0.010   Min.   :  0.000        Min.   : 6.00    Min.   :    0
 1st Qu.: 2.493   1st Qu.:  0.000        1st Qu.:78.75    1st Qu.:    0
 Median : 5.285   Median :  0.000        Median :93.00    Median :   17
 Mean   : 5.288   Mean   :  2.384        Mean   :82.43    Mean   : 1503
 3rd Qu.: 8.018   3rd Qu.:  0.000        3rd Qu.:97.00    3rd Qu.:  202
 Max.   :10.660   Max.   :364.975        Max.   :99.00    Max.   :90387
 NA's   :177                            NA's   :9
      BMI         under.five.deaths     Polio        Total.expenditure
 Min.   : 2.50   Min.   :   0.00    Min.   : 5.00    Min.   :6.00
 1st Qu.:24.30   1st Qu.:   0.00    1st Qu.:83.00    1st Qu.:6.54
 Median :48.60   Median :   3.00    Median :93.00    Median :7.08
 Mean   :42.75   Mean   :  31.61    Mean   :83.21    Mean   :7.08
 3rd Qu.:61.40   3rd Qu.:  21.00    3rd Qu.:97.00    3rd Qu.:7.62
 Max.   :77.60   Max.   :1100.00    Max.   :99.00    Max.   :8.16
 NA's   :2                                           NA's   :181
   Diphtheria        HIV.AIDS            GDP           Population
```

```
Min.   : 6.00    Min.    :0.1000   Min.    :   33.68   Min.   :       2966
1st Qu.:83.50    1st Qu.:0.1000    1st Qu.:  766.01    1st Qu.:    268071
Median :93.00    Median :0.1000    Median :  2916.23   Median :   2076086
Mean   :84.63    Mean   :0.6607    Mean   :  7185.33   Mean   :  11097408
3rd Qu.:97.00    3rd Qu.:0.4000    3rd Qu.: 7290.11    3rd Qu.:  9940296
Max.   :99.00    Max.   :9.3000    Max.   :66346.52    Max.   :258162113
                                   NA's   :29          NA's   :41
thinness..1.19.years thinness.5.9.years Income.composition.of.resources
Min.   : 0.100       Min.    : 0.100    Min.   :0.3470
1st Qu.: 1.500       1st Qu.: 1.500     1st Qu.:0.5650
Median : 3.500       Median : 3.400     Median :0.7230
Mean   : 4.535       Mean    : 4.576    Mean   :0.6917
3rd Qu.: 6.500       3rd Qu.: 6.400     3rd Qu.:0.7980
Max.   :26.700       Max.    :27.300    Max.   :0.9480
NA's   :2            NA's    :2         NA's   :10
  Schooling
Min.   : 4.90
1st Qu.:10.80
Median :13.10
Mean   :12.93
3rd Qu.:15.00
Max.   :20.40
NA's   :10
```

3. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

Tirar Alcohol, Total.expenditure

```
life_2015_clean<- subset(life_2015_clean, select=-c(Alcohol, Total.expenditure))
life_2015_clean <- na.omit(life_2015_clean) ## eliminando muitos dados.
```

```
modreg_trein <- lm(Life.expectancy ~ Status + Adult.Mortality + infant.deaths + percentage.expenditure + He

summary(modreg_trein)
```

```
Call:
lm(formula = Life.expectancy ~ Status + Adult.Mortality + infant.deaths +
```

```
        percentage.expenditure + Hepatitis.B + Measles + BMI + under.five.deaths +
        Polio + Diphtheria + HIV.AIDS + GDP + Population + thinness..1.19.years +
        thinness.5.9.years + Income.composition.of.resources + Schooling,
        data = life_2015_clean)

Residuals:
    Min      1Q  Median      3Q     Max
-7.3326 -1.4047  0.0247  1.5478  7.9440

Coefficients:
                                 Estimate Std. Error t value Pr(>|t|)
(Intercept)                     5.083e+01  3.024e+00  16.807  < 2e-16 ***
Status                         -3.824e-01  8.332e-01  -0.459   0.6472
Adult.Mortality                -2.077e-02  3.619e-03  -5.738 8.29e-08 ***
infant.deaths                   6.626e-02  3.291e-02   2.013   0.0465 *
percentage.expenditure          5.575e-03  7.362e-03   0.757   0.4505
Hepatitis.B                     4.311e-02  2.264e-02   1.904   0.0595 .
Measles                        -5.027e-05  5.741e-05  -0.876   0.3832
BMI                            -9.085e-03  1.554e-02  -0.585   0.5600
under.five.deaths              -4.811e-02  2.359e-02  -2.040   0.0437 *
Polio                           1.179e-02  1.271e-02   0.928   0.3553
Diphtheria                     -1.148e-02  2.636e-02  -0.435   0.6641
HIV.AIDS                       -4.858e-01  2.243e-01  -2.166   0.0324 *
GDP                             5.950e-06  3.011e-05   0.198   0.8437
Population                     -7.918e-10  9.586e-09  -0.083   0.9343
thinness..1.19.years           -1.192e-01  2.343e-01  -0.509   0.6119
thinness.5.9.years             -2.030e-02  2.291e-01  -0.089   0.9296
Income.composition.of.resources 3.331e+01  4.991e+00   6.674 9.93e-10 ***
Schooling                      -5.244e-02  2.407e-01  -0.218   0.8279
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.7 on 112 degrees of freedom
Multiple R-squared:  0.901,Adjusted R-squared:  0.886
F-statistic: 59.99 on 17 and 112 DF,  p-value: < 2.2e-16
```

4. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = Life.expectancy ~ Adult.Mortality + infant.deaths +
    Hepatitis.B + under.five.deaths + HIV.AIDS + thinness..1.19.years +
    Income.composition.of.resources, data = life_2015_clean)
```

5. Teste de Shapiro Finalmente, aplicar o teste de `shapiro` nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.98739, p-value = 0.2784
```

p-value = 0.2784 ¡=¿ p-value maior que 0.05 =¿ não rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo é distribuido normalmente.

1.2 Consumo de Cigarro (não normal)

- **Modelar quantidade de venda (sales).**

1.2.1 Sobre o Conjunto

- Usado em:
  - Baltagi, Badi H. (2001) Econometric Analysis of Panel Data, 2nd ed., John Wiley and Sons.

- Baltagi, Badi H. (2013) Econometric Analysis of Panel Data, 5th ed., John Wiley and Sons.
- Baltagi, B.H. and D. Levin (1992) "Cigarette taxation: raising revenues and reducing consumption", Structural Changes and Economic Dynamics, 3(2), pp. 321–335.
- Baltagi, B.H., J.M. Griffin and W. Xiong (2000) "To pool or not to pool: homogeneous versus heterogeneous estimators applied to cigarette demand", Review of Economics and Statistics, 82(1), pp. 117–126.

- Dados: anos 1963-1992

    - State: estados norte americanos, $\{1, 2, 3, \ldots, 51\}$.
    - Year: Anos 63-92.
    - Price: preço do maço.
    - Pop: população de fumantes.
    - Pop16: população acima de 16.
    - CPI: índice do preço (ideal) dado pelo consumidor.
    - NDI: Salário líquido per capta.
    - Sales: venda de cigarro por maço.
    - Pimin: preço mínimo de cigarro em estados vizinhos

1.2.2 Como utilizar pelo R

O `conjunto de dados` se encontra sob o pacote `Ecdat` (Econometrics Datasets [Conjuntos de Econometria]). Desta forma, precisamos instalá-lo.

```
install.packages("Ecdat",mirror="https://vps.fmvz.usp.br/CRAN/")
```

Após instalação, precisamos invocar o pacote.

```
load(Ecdat)
```

Finalmente, podemos acessar o `conjunto`.

```
cigarro <- data("Cigar")
cigarro
```

1.2.3 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o `conjunto` cigarro.csv da seguinte maneira.

```r
data <- read.csv('./data/csv/cigarro.csv')
cigarro<- subset(data, year==90)
head(cigarro,5)
```

```
     state year price  pop      pop16    cpi   ndi   sales pimin
28   1     90    139.1  4129.2   3148.6  130.7 12806 108.6 132.3
58   3     90    130.2  3598.2   2703.7  130.7 13826  88.9 133.6
88   4     90    141.2  2411.1   1834.9  130.7 12370 113.1 129.1
118  5     90    163.8 29602.1  22490.6  130.7 17384  77.8 130.2
148  7     90    171.2  3242.9   2567.1  130.7 21447  91.5 150.9
```

1.2.4 Regressão e Teste de Shapiro (não normal)

1. Retirar valores nominais do título do estado

```r
cigarro_clean <- subset(cigarro, select=-c(year, cpi))
```

2. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```r
modreg_trein <- lm(sales ~ . , cigarro_clean)
summary(modreg_trein)
```

```
Call:
lm(formula = sales ~ ., data = cigarro_clean)

Residuals:
    Min      1Q  Median      3Q     Max
-34.966 -11.873   0.664   7.174  59.369

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 203.502135  49.643084   4.099 0.000203 ***
```

```
state          -0.156382    0.214396   -0.729 0.470110
price          -0.732567    0.299148   -2.449 0.018930 *
pop            -0.022894    0.019797   -1.156 0.254522
pop16           0.029419    0.025926    1.135 0.263425
ndi             0.001274    0.001646    0.774 0.443729
pimin          -0.066073    0.409737   -0.161 0.872724
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 20.62 on 39 degrees of freedom
Multiple R-squared:  0.2254,Adjusted R-squared:  0.1062
F-statistic: 1.891 on 6 and 39 DF,  p-value: 0.1069
```

3. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=284.83
sales ~ state + price + pop + pop16 + ndi + pimin

        Df Sum of Sq   RSS    AIC
- pimin  1     11.06 16596 282.86
- state  1    226.25 16812 283.45
- ndi    1    254.62 16840 283.53
- pop16  1    547.55 17133 284.32
- pop    1    568.76 17154 284.38
<none>               16585 284.83
- price  1   2550.22 19135 289.41

Step:  AIC=282.86
sales ~ state + price + pop + pop16 + ndi

        Df Sum of Sq   RSS    AIC
- state  1     233.4 16830 281.50
```

11

```
- ndi    1      243.8 16840 281.53
- pop16  1      583.1 17179 282.45
- pop    1      602.1 17198 282.50
<none>                16596 282.86
+ pimin  1       11.1 16585 284.83
- price  1     3241.1 19837 289.07

Step:  AIC=281.5
sales ~ price + pop + pop16 + ndi


        Df Sum of Sq   RSS    AIC
- ndi    1      323.5 17153 280.38
- pop16  1      563.4 17393 281.02
- pop    1      580.4 17410 281.06
<none>                16830 281.50
+ state  1      233.4 16596 282.86
+ pimin  1       18.2 16812 283.45
- price  1     3312.6 20142 287.77

Step:  AIC=280.38
sales ~ price + pop + pop16


        Df Sum of Sq   RSS    AIC
<none>                17153 280.38
- pop16  1    1198.70 18352 281.49
+ ndi    1     323.54 16830 281.50
- pop    1    1209.90 18363 281.51
+ state  1     313.18 16840 281.53
+ pimin  1       1.27 17152 282.38
- price  1    3005.27 20158 285.81

Call:
lm(formula = sales ~ price + pop + pop16, data = cigarro_clean)

Coefficients:
(Intercept)          price             pop          pop16
  199.94492       -0.67052        -0.03004        0.03899
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = sales ~ price + pop + pop16, data = cigarro_clean)
```

4. Teste de Shapiro Finalmente, aplicar o teste de **shapiro** nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.92433, p-value = 0.005309
```

p-value = 0.005309 ¡=¿ p-value menor que 0.05 =¿ rejeitamos H0, em
que, H0: resíduo distribuido normalmente.

Portanto, o resíduo não é distribuido normalmente.

1.3 Inteligência de prodígios (normal)

- **Modele o IQ da criança com as outras variáveis**

1.3.1 Sobre o `Conjunto`

- Referências:

  – Graybill, F.A. & Iyer, H.K., (1994) Regression Analysis: Concepts and Applications, Duxbury, p. 511-6.

- Dados:

  1. IQ da Criança.
  2. IQ Pai.
  3. IQ Mãe.
  4. Período em meses, até primeiras palavras.
  5. Período em meses, até quanto contou até dez.
  6. Tempo passado, pelos pais, lendo livros, semanalmente.
  7. Tempo passado assistindo programas educativos, semanalmente.
  8. Tempo assistindo desenhos (`cartoons`), semanalmente.

1.3.2 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o `conjunto` gifted.csv da seguinte maneira.

```
data <- read.csv('./data/csv/gifted.csv')
head(data,5)
```

	score	fatheriq	motheriq	speak	count	read	edutv	cartoons
1	159	115	117	18	26	1.9	3.00	2.00
2	164	117	113	20	37	2.5	1.75	3.25
3	154	115	118	20	32	2.2	2.75	2.50
4	157	113	131	12	24	1.7	2.75	2.25
5	156	110	109	17	34	2.2	2.25	2.50

1.3.3 Regressão e Teste de Shapiro (normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```
modreg_trein <- lm(score ~ . , data)
summary(modreg_trein)
```

```
Call:
lm(formula = score ~ ., data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-4.8064 -1.5898  0.0479  1.7474  5.2905

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 75.50849   24.02618   3.143  0.00393 **
fatheriq     0.25249    0.13756   1.835  0.07707 .
motheriq     0.40007    0.07291   5.488 7.33e-06 ***
speak        0.18764    0.14767   1.271  0.21429
count        0.20649    0.26631   0.775  0.44462
read         7.54405    5.58640   1.350  0.18769
```

```
edutv       -4.20244    2.24503  -1.872  0.07170 .
cartoons    -3.33899    2.01808  -1.655  0.10919
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.591 on 28 degrees of freedom
Multiple R-squared:  0.7496,Adjusted R-squared:  0.687
F-statistic: 11.97 on 7 and 28 DF,  p-value: 5.803e-07
```

2. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=75.49
score ~ fatheriq + motheriq + speak + count + read + edutv +
    cartoons

           Df Sum of Sq    RSS    AIC
- count     1     4.034 191.94 74.251
<none>                    187.90 75.486
- speak     1    10.836 198.74 75.505
- read      1    12.238 200.14 75.758
- cartoons  1    18.371 206.27 76.844
- fatheriq  1    22.609 210.51 77.577
- edutv     1    23.514 211.42 77.731
- motheriq  1   202.081 389.98 99.773

Step:  AIC=74.25
score ~ fatheriq + motheriq + speak + read + edutv + cartoons

           Df Sum of Sq    RSS    AIC
- speak     1     7.829 199.77 73.690
<none>                    191.94 74.251
+ count     1     4.034 187.90 75.486
```

```
- fatheriq   1     21.119 213.06 76.009
- cartoons   1     22.467 214.40 76.236
- edutv      1     29.657 221.59 77.424
- read       1    182.630 374.57 96.321
- motheriq   1    214.969 406.91 99.302


Step:  AIC=73.69
score ~ fatheriq + motheriq + read + edutv + cartoons

           Df Sum of Sq    RSS    AIC
<none>                   199.77 73.690
+ speak      1     7.829 191.94 74.251
- fatheriq   1    20.167 219.93 75.153
+ count      1     1.027 198.74 75.505
- cartoons   1    25.102 224.87 75.952
- edutv      1    34.053 233.82 77.357
- read       1   199.869 399.63 96.653
- motheriq   1   219.573 419.34 98.386


Call:
lm(formula = score ~ fatheriq + motheriq + read + edutv + cartoons,
    data = data)


Coefficients:
(Intercept)      fatheriq      motheriq          read         edutv      cartoons
    79.0468        0.2374        0.4121       11.9013       -4.8881       -3.8202
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = score ~ fatheriq + motheriq + read + edutv + cartoons,
    data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de **shapiro** nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.97689, p-value = 0.6398
```

p-value = 0.6398 ¡=¿ p-value maior que 0.05 =¿ não rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo é distribuido normalmente.

1.4 SAT - Professores (não normal)

- **Modelar variável SAT (nota geral)**

1.4.1 Sobre o `Conjunto`

- Dados:

  - State: estado norte americano
  - Expend: termo médio de aula assistida diária.
  - Ratio: razão de alunos por professor.
  - Salary: salário do professor médio, anual.
  - Frac: percentagem de alunos elegíveis a participar do SAT.
  - Verbal: nota pra proficiência verbal no SAT.
  - Math: nota para proficiência em exatadas no SAT.
  - SAT: nota geral do SAT final.

1.4.2 Como utilizar pelo R

O `conjunto de dados` se encontra sob o pacote `mosaicData`. Desta forma, precisamos instalá-lo.

```
install.packages("mosaicData",mirror="https://vps.fmvz.usp.br/CRAN/")
```

Após instalação, precisamos invocar o pacote,

```
library(mosaicData)
```

Finalmente, podemos acessar o `conjunto`,

```
data <- SAT
head(data)
```

1.4.3 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto professores-SAT da seguinte maneira.

```
data <- read.csv('./data/csv/professores-SAT.csv')
head(data,5)
```

```
    state       expend ratio salary frac verbal math sat
1 Alabama       4.405  17.2  31.144  8    491    538  1029
2 Alaska        8.963  17.6  47.951 47    445    489   934
3 Arizona       4.778  19.3  32.175 27    448    496   944
4 Arkansas      4.459  17.1  28.934  6    482    523  1005
5 California    4.992  24.0  41.078 45    417    485   902
```

1.4.4 Regressão e Teste de Shapiro (não normal)

1. Retirar valores anuais

   ```
   data <- subset(data, select=-c(state))
   ```

2. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

   ```
   modreg_trein <- lm(sat ~ . , data)
   summary(modreg_trein)
   ```

```
Call:
lm(formula = sat ~ ., data = data)

Residuals:
      Min        1Q     Median        3Q       Max
```

```
-7.624e-14 -1.386e-14 -3.695e-15  6.353e-15  9.046e-14

Coefficients:
              Estimate Std. Error    t value Pr(>|t|)
(Intercept) -2.305e-13  1.416e-13 -1.628e+00  0.11082
expend      -6.673e-15  8.724e-15 -7.650e-01  0.44847
ratio       -6.881e-16  2.719e-15 -2.530e-01  0.80140
salary      -9.299e-16  1.978e-15 -4.700e-01  0.64063
frac         1.608e-15  4.064e-16  3.957e+00  0.00028 ***
verbal       1.000e+00  5.210e-16  1.919e+15  < 2e-16 ***
math         1.000e+00  4.233e-16  2.362e+15  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.693e-14 on 43 degrees of freedom
Multiple R-squared:        1,Adjusted R-squared:        1
F-statistic: 6.305e+31 on 6 and 43 DF,  p-value: < 2.2e-16
```

3. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=-3118.1
sat ~ expend + ratio + salary + frac + verbal + math


        Df Sum of Sq    RSS     AIC
- ratio  1       0.0    0.0 -3188.2
- expend 1       0.0    0.0 -3178.6
- salary 1       0.0    0.0 -3152.6
- frac   1       0.0    0.0 -3130.1
<none>                  0.0 -3118.1
- verbal 1    2671.0 2671.0   210.9
- math   1    4046.3 4046.3   231.7
```

```
Step:  AIC=-3188.21
sat ~ expend + salary + frac + verbal + math



          Df Sum of Sq    RSS      AIC
<none>                    0.0 -3188.2
+ ratio   1        0.0    0.0 -3186.3
- frac    1        0.0    0.0 -3178.7
- expend  1        0.0    0.0 -3169.3
- salary  1        0.0    0.0 -3165.1
- verbal  1     2773.1 2773.1    210.8
- math    1     4090.2 4090.2    230.2

Call:
lm(formula = sat ~ expend + salary + frac + verbal + math, data = data)

Coefficients:
(Intercept)       expend       salary        frac       verbal         math
 -2.836e-13     8.486e-15   -1.077e-15    3.896e-16    1.000e+00    1.000e+00


Start:  AIC=-3118.1
sat ~ expend + ratio + salary + frac + verbal + math



          Df Sum of Sq    RSS      AIC
- ratio   1        0.0    0.0 -3188.2
- expend  1        0.0    0.0 -3178.6
- salary  1        0.0    0.0 -3152.6
- frac    1        0.0    0.0 -3130.1
<none>                    0.0 -3118.1
- verbal  1     2671.0 2671.0    210.9
- math    1     4046.3 4046.3    231.7

Step:  AIC=-3188.21
sat ~ expend + salary + frac + verbal + math
```

```
         Df Sum of Sq     RSS      AIC
<none>                    0.0 -3188.2
+ ratio   1        0.0    0.0 -3186.3
- frac    1        0.0    0.0 -3178.7
- expend  1        0.0    0.0 -3169.3
- salary  1        0.0    0.0 -3165.1
- verbal  1     2773.1 2773.1   210.8
- math    1     4090.2 4090.2   230.2


Call:
lm(formula = sat ~ expend + salary + frac + verbal + math, data = data)


Coefficients:
(Intercept)        expend        salary          frac        verbal          math
 -2.836e-13      8.486e-15     -1.077e-15     3.896e-16     1.000e+00     1.000e+00
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = sat ~ expend + salary + frac + verbal + math, data = data)
```

4. Teste de Shapiro Finalmente, aplicar o teste de `shapiro` nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.9022, p-value = 0.0005685
```

p-value $= 0.005685 \Rightarrow$ p-value menor que $0.05 \Rightarrow$ rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo não é distribuido normalmente.

1.5   Toxicidade (não normal)

- **Modelar nível de toxicidade aquática de ácidos caboxílicos, baseado nos outros descritores moleculares.**

1.5.1   Sobre o `Conjunto`

- Dados:

    – toxicity

    toxicidade aquática, definida como o $log(\text{IGC50}^{-1})$; tipicamente, a "reposta".

    – logKow log Kow, coeficiente de parcionamento

    – pKa pKa: constante dissociativa

    – ELUMO Energia do menor orbital molecular ocupado

    – Ecarb Estado eletrotopolófico do grupo carboxílico

    – Emet Estado eletrotopolófico do grupo metil

    – RM Reflectibilidade Molar

    – IR Index de Refração

    – Ts Tensão superficial

    – P Polaridade

1.5.2   Como utilizar pelo R

O `conjunto de dados` se encontra sob o pacote `robustbase`. Desta forma, precisamos instalá-lo.

```
install.packages("robustbase",mirror="https://vps.fmvz.usp.br/CRAN/")
```

Após instalação, precisamos invocar o pacote,

```
library(robustbase)
```

Finalmente, podemos acessar o `conjunto`,

```
data <- toxicity
head(data)
```

1.5.3 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto toxicidade da seguinte maneira.

```
data <- read.csv('./data/csv/toxicity.csv')
head(data,5)
```

1.5.4 Regressão e Teste de Shapiro (não normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```
modreg_trein <- lm(toxicity ~ . , data)
summary(modreg_trein)
```

```
Call:
lm(formula = toxicity ~ ., data = data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.36704 -0.09072 -0.01605  0.05775  0.50947

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -6.973446   6.538420  -1.067  0.29529
logKow       0.317054   0.136360   2.325  0.02754 *
pKa          0.059883   0.184185   0.325  0.74751
ELUMO       -0.201126   0.057242  -3.514  0.00152 **
Ecarb       -0.027091   0.173513  -0.156  0.87705
Emet         0.012661   0.036188   0.350  0.72906
RM          -0.014451   0.017489  -0.826  0.41562
IR           5.896792   5.156774   1.144  0.26251
Ts          -0.014075   0.011667  -1.206  0.23777
P            0.008387   0.013845   0.606  0.54957
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Residual standard error: 0.184 on 28 degrees of freedom
Multiple R-squared:  0.8463,Adjusted R-squared:  0.7969
F-statistic: 17.14 on 9 and 28 DF,  p-value: 3.52e-09
```

2. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=-120.27
toxicity ~ logKow + pKa + ELUMO + Ecarb + Emet + RM + IR + Ts +
    P

          Df Sum of Sq      RSS      AIC
- Ecarb    1    0.00083  0.94855  -122.23
- pKa      1    0.00358  0.95131  -122.12
- Emet     1    0.00414  0.95187  -122.10
- P        1    0.01242  0.96015  -121.77
- RM       1    0.02311  0.97084  -121.35
- IR       1    0.04426  0.99199  -120.53
- Ts       1    0.04926  0.99699  -120.34
<none>                   0.94773  -120.27
- logKow   1    0.18299  1.13072  -115.56
- ELUMO    1    0.41786  1.36559  -108.39

Step:  AIC=-122.24
toxicity ~ logKow + pKa + ELUMO + Emet + RM + IR + Ts + P

          Df Sum of Sq      RSS      AIC
- pKa      1    0.00299  0.95155  -124.12
- Emet     1    0.01030  0.95886  -123.83
- P        1    0.01259  0.96115  -123.73
- RM       1    0.04377  0.99232  -122.52
- IR       1    0.04578  0.99433  -122.44
<none>                   0.94855  -122.23
```

24

```
- Ts       1    0.06045 1.00900 -121.89
+ Ecarb    1    0.00083 0.94773 -120.27
- logKow   1    0.18840 1.13695 -117.35
- ELUMO    1    0.44904 1.39759 -109.51


Step:  AIC=-124.12
toxicity ~ logKow + ELUMO + Emet + RM + IR + Ts + P


          Df Sum of Sq     RSS      AIC
- Emet     1    0.01012 0.96167 -125.71
- P        1    0.03449 0.98604 -124.76
- IR       1    0.04720 0.99874 -124.28
<none>                   0.95155 -124.12
- Ts       1    0.05972 1.01127 -123.80
- RM       1    0.07118 1.02273 -123.37
+ pKa      1    0.00299 0.94855 -122.23
+ Ecarb    1    0.00024 0.95131 -122.12
- logKow   1    0.31676 1.26831 -115.20
- ELUMO    1    0.48298 1.43453 -110.52


Step:  AIC=-125.71
toxicity ~ logKow + ELUMO + RM + IR + Ts + P


          Df Sum of Sq     RSS      AIC
- P        1    0.02993 0.99160 -126.55
- IR       1    0.03942 1.00109 -126.19
<none>                   0.96167 -125.71
- Ts       1    0.05346 1.01512 -125.66
- RM       1    0.06258 1.02424 -125.32
+ Emet     1    0.01012 0.95155 -124.12
+ Ecarb    1    0.00513 0.95653 -123.92
+ pKa      1    0.00281 0.95886 -123.83
- logKow   1    0.42750 1.38917 -113.74
- ELUMO    1    0.61370 1.57537 -108.96


Step:  AIC=-126.55
toxicity ~ logKow + ELUMO + RM + IR + Ts


          Df Sum of Sq     RSS      AIC
- IR       1    0.01185 1.00345 -128.10
```

```
- Ts        1   0.02459 1.01619 -127.62
<none>                  0.99160 -126.55
+ P         1   0.02993 0.96167 -125.71
+ pKa       1   0.02228 0.96932 -125.41
- RM        1   0.08551 1.07711 -125.41
+ Emet      1   0.00556 0.98604 -124.76
+ Ecarb     1   0.00296 0.98864 -124.66
- ELUMO     1   0.60776 1.59936 -110.38
- logKow    1   0.90448 1.89608 -103.92

Step:  AIC=-128.1
toxicity ~ logKow + ELUMO + RM + Ts


          Df Sum of Sq    RSS      AIC
- Ts        1   0.01314 1.0166 -129.60
<none>                  1.0034 -128.10
- RM        1   0.07447 1.0779 -127.38
+ IR        1   0.01185 0.9916 -126.55
+ Emet      1   0.00255 1.0009 -126.19
+ P         1   0.00236 1.0011 -126.19
+ Ecarb     1   0.00107 1.0024 -126.14
+ pKa       1   0.00003 1.0034 -126.10
- ELUMO     1   0.67820 1.6817 -110.48
- logKow    1   0.89263 1.8961 -105.92

Step:  AIC=-129.6
toxicity ~ logKow + ELUMO + RM


          Df Sum of Sq    RSS       AIC
<none>                  1.0166 -129.603
+ Ts        1   0.01314 1.0035 -128.097
+ Ecarb     1   0.00344 1.0132 -127.732
+ Emet      1   0.00306 1.0135 -127.717
+ pKa       1   0.00059 1.0160 -127.625
+ P         1   0.00046 1.0161 -127.620
+ IR        1   0.00040 1.0162 -127.618
- RM        1   0.30329 1.3199 -121.682
- ELUMO     1   0.75682 1.7734 -110.458
- logKow    1   2.97335 3.9899  -79.645
```

```
Call:
lm(formula = toxicity ~ logKow + ELUMO + RM, data = data)

Coefficients:
(Intercept)          logKow          ELUMO              RM
    0.42898         0.39055       -0.18234        -0.01294
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = toxicity ~ logKow + ELUMO + RM, data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de `shapiro` nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.93867, p-value = 0.03793
```

p-value = 0.03793 ¡=¿ p-value menor que 0.05 =¿ rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo não é distribuido normalmente.

1.6   Fertilidade Feminina (não normal)

- **Modelar MeanAFC** o qual diretamente empacta a habilidade de ter filhos.

1.6.1   Sobre o `Conjunto`

- Dados:
  - Idade
  - LowAFC: Conta da menor quantidade de folículos antrais.

- MeanAFC: Média de folículos antrais.
- FSH: Máxima quantidade de níveis de hormônios estimulantes aos folículos.
- E2: Nível de fertilidade.
- MaxE2: Máximo nível de fertilidade.
- MaxDailyGn: Nível máximo de gonadotrofina.
- TotalGn: Nível total de gonadotrofina.
- Oocytes: Quantidade de ovócitos/oócitos.
- Embryos: Quantidade de embriões.

1.6.2 Como utilizar pelo R

O `conjunto de dados` se encontra sob o pacote `Stat2Data`. Desta forma, precisamos instalá-lo.

```
install.packages("Stat2Data",mirror="https://vps.fmvz.usp.br/CRAN/")
```

Após instalação, precisamos invocar o pacote,

```
library(Stat2Data)
```

Finalmente, podemos acessar o `conjunto`,

```
data <- data("Fertility")
head(data)
```

1.6.3 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto Fertilidade da seguinte maneira.

```
data <- read.csv('./data/csv/Fertility.csv')
head(data,5)
```

	Age	LowAFC	MeanAFC	FSH	E2	MaxE2	MaxDailyGn	TotalGn	Oocytes	Embryos
1	40	40	51.5	5.3	45	1427	300	2700	25	13
2	37	41	41.0	7.1	53	802	225	1800	7	6

```
3 40  38      41.0    4.9 40 4533  450         4850    27      15
4 40  36      37.5    3.9 26 1804  300         2700     9       4
5 30  36      36.0    4.0 49 2526  150         1500    19      12
```

1.6.4   Regressão e Teste de Shapiro (não normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```
modreg_trein <- lm(MeanAFC ~ . , data)
summary(modreg_trein)
```

```
Call:
lm(formula = MeanAFC ~ ., data = data)

Residuals:
    Min     1Q  Median     3Q     Max
-3.2817 -1.2920 -0.7525  0.5865 10.8763

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.708e-01  1.212e+00   0.224 0.823268
Age         -3.723e-02  3.162e-02  -1.177 0.239918
LowAFC       1.014e+00  2.077e-02  48.791  < 2e-16 ***
FSH          8.444e-02  7.315e-02   1.154 0.249177
E2           5.181e-04  8.150e-03   0.064 0.949356
MaxE2       -1.088e-04  1.842e-04  -0.591 0.555048
MaxDailyGn   2.809e-03  2.637e-03   1.065 0.287506
TotalGn     -6.837e-05  2.147e-04  -0.318 0.750353
Oocytes      1.311e-01  3.388e-02   3.868 0.000133 ***
Embryos     -6.923e-02  4.605e-02  -1.503 0.133740
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.21 on 323 degrees of freedom
Multiple R-squared:  0.9139,Adjusted R-squared:  0.9115
F-statistic: 380.9 on 9 and 323 DF,  p-value: < 2.2e-16
```

2. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=537.92
MeanAFC ~ Age + LowAFC + FSH + E2 + MaxE2 + MaxDailyGn + TotalGn +
    Oocytes + Embryos

              Df Sum of Sq      RSS      AIC
- E2           1       0.0   1577.3   535.92
- TotalGn      1       0.5   1577.8   536.02
- MaxE2        1       1.7   1579.0   536.28
- MaxDailyGn   1       5.5   1582.8   537.09
- FSH          1       6.5   1583.8   537.29
- Age          1       6.8   1584.0   537.34
<none>                       1577.3   537.92
- Embryos      1      11.0   1588.3   538.24
- Oocytes      1      73.0   1650.3   550.99
- LowAFC       1   11624.9 13202.1  1243.44

Step:  AIC=535.92
MeanAFC ~ Age + LowAFC + FSH + MaxE2 + MaxDailyGn + TotalGn +
    Oocytes + Embryos

              Df Sum of Sq      RSS      AIC
- TotalGn      1       0.5   1577.8   534.03
- MaxE2        1       1.7   1579.0   534.28
- MaxDailyGn   1       5.5   1582.8   535.09
- FSH          1       6.5   1583.8   535.29
- Age          1       6.8   1584.1   535.35
<none>                       1577.3   535.92
- Embryos      1      11.0   1588.3   536.24
+ E2           1       0.0   1577.3   537.92
- Oocytes      1      73.4   1650.6   549.06
- LowAFC       1   11816.3 13393.6  1246.23
```

30

```
Step:  AIC=534.03
MeanAFC ~ Age + LowAFC + FSH + MaxE2 + MaxDailyGn + Oocytes +
    Embryos

              Df Sum of Sq      RSS      AIC
- MaxE2        1        1.7   1579.5   532.38
- FSH          1        6.1   1583.9   533.31
- Age          1        6.8   1584.6   533.46
<none>                        1577.8   534.03
- MaxDailyGn   1       10.1   1587.9   534.16
- Embryos      1       11.0   1588.8   534.35
+ TotalGn      1        0.5   1577.3   535.92
+ E2           1        0.0   1577.8   536.02
- Oocytes      1       73.3   1651.1   547.14
- LowAFC       1    11836.0  13413.8  1244.73

Step:  AIC=532.38
MeanAFC ~ Age + LowAFC + FSH + MaxDailyGn + Oocytes + Embryos

              Df Sum of Sq      RSS      AIC
- FSH          1        6.3   1585.8   531.71
- Age          1        7.3   1586.8   531.92
<none>                        1579.5   532.38
- MaxDailyGn   1       11.9   1591.3   532.88
- Embryos      1       12.0   1591.5   532.90
+ MaxE2        1        1.7   1577.8   534.03
+ TotalGn      1        0.5   1579.0   534.28
+ E2           1        0.0   1579.5   534.38
- Oocytes      1       72.5   1651.9   545.32
- LowAFC       1    11839.7  13419.2  1242.87

Step:  AIC=531.71
MeanAFC ~ Age + LowAFC + MaxDailyGn + Oocytes + Embryos

              Df Sum of Sq      RSS      AIC
- Age          1        6.8   1592.5   531.13
<none>                        1585.8   531.71
- Embryos      1       11.9   1597.7   532.20
+ FSH          1        6.3   1579.5   532.38
```

```
+ MaxE2         1        1.9  1583.9   533.31
- MaxDailyGn    1       18.4  1604.2   533.55
+ TotalGn       1        0.1  1585.7   533.69
+ E2            1        0.0  1585.7   533.70
- Oocytes       1       68.8  1654.5   543.84
- LowAFC        1    11935.7 13521.4  1243.39

Step:  AIC=531.13
MeanAFC ~ LowAFC + MaxDailyGn + Oocytes + Embryos

             Df Sum of Sq      RSS      AIC
<none>                      1592.5   531.13
- Embryos       1       10.8  1603.3   531.37
- MaxDailyGn    1       11.8  1604.3   531.58
+ Age           1        6.8  1585.8   531.71
+ FSH           1        5.8  1586.8   531.92
+ MaxE2         1        2.4  1590.1   532.62
+ TotalGn       1        0.1  1592.5   533.11
+ E2            1        0.0  1592.5   533.12
- Oocytes       1       65.5  1658.0   542.54
- LowAFC        1    11936.3 13528.8  1241.58

Call:
lm(formula = MeanAFC ~ LowAFC + MaxDailyGn + Oocytes + Embryos,
    data = data)

Coefficients:
(Intercept)       LowAFC   MaxDailyGn        Oocytes       Embryos
   -0.40456      1.01104      0.00182        0.11833      -0.06786
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = MeanAFC ~ LowAFC + MaxDailyGn + Oocytes + Embryos,
    data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de **shapiro** nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.76651, p-value < 2.2e-16
```

p-value ¡ 2.2e-16 ¡=¿ p-value bem menor que 0.05 =¿ rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo não é distribuido normalmente.

1.7 Atitudes em relação à empresa (normal)

- **Modelar e modelar o rating**

1.7.1 Sobre o Conjunto

- Dados: (em percentagem)

  - Complaints: percentagem de resoluções de reclamações.
  - Privileges: percentagem de intolerância de privilégios.
  - Learning: percentagem de oportunidade de aprendizado.
  - Raises: percetagem de aumento correspondente à perfôrmance.
  - Critical: percentagem de atitudes e críticas exacerbadas.
  - Advancel: percentadem de evolução percebida da empresa e posto.
  - Rating: avaliação geral positiva da empresa

1.7.2 Como utilizar pelo R

O conjunto de dados se encontra sob o pacote datasets. Desta forma, precisamos instalá-lo.

```
install.packages("datasets",mirror="https://vps.fmvz.usp.br/CRAN/")
```

Após instalação, precisamos invocar o pacote,

```
library(datasets)
```

Finalmente, podemos acessar o `conjunto`,

```
data <- data("attitude")
head(data)
```

1.7.3 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local,
pode-se chamar o conjunto Atitude da seguinte maneira.

```
data <- read.csv('./data/csv/attitude.csv')
head(data,5)
```

	rating	complaints	privileges	learning	raises	critical	advance
1	43	51	30	39	61	92	45
2	63	64	51	54	63	73	47
3	71	70	68	69	76	86	48
4	61	63	45	47	54	84	35
5	81	78	56	66	71	83	47

1.7.4 Regressão e Teste de Shapiro (normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas,
   vamos aplicar a regressão linear múltipla,

   ```
   modreg_trein <- lm(rating ~ . , data)
   summary(modreg_trein)
   ```

   ```
   Call:
   lm(formula = rating ~ ., data = data)

   Residuals:
       Min      1Q   Median      3Q     Max
   -10.9418  -4.3555   0.3158   5.5425  11.5990
   ```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 10.78708   11.58926   0.931 0.361634
complaints   0.61319    0.16098   3.809 0.000903 ***
privileges  -0.07305    0.13572  -0.538 0.595594
learning     0.32033    0.16852   1.901 0.069925 .
raises       0.08173    0.22148   0.369 0.715480
critical     0.03838    0.14700   0.261 0.796334
advance     -0.21706    0.17821  -1.218 0.235577
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.068 on 23 degrees of freedom
Multiple R-squared:  0.7326,Adjusted R-squared:  0.6628
F-statistic:  10.5 on 6 and 23 DF,  p-value: 1.24e-05
```

2. StepAIC

```r
library(MASS)
```

```r
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=123.36
rating ~ complaints + privileges + learning + raises + critical +
    advance

              Df Sum of Sq    RSS    AIC
- critical     1      3.41 1152.4 121.45
- raises       1      6.80 1155.8 121.54
- privileges   1     14.47 1163.5 121.74
- advance      1     74.11 1223.1 123.24
<none>                     1149.0 123.36
- learning     1    180.50 1329.5 125.74
- complaints   1    724.80 1873.8 136.04

Step:  AIC=121.45
```

```
rating ~ complaints + privileges + learning + raises + advance

            Df Sum of Sq    RSS    AIC
- raises      1     10.61 1163.0 119.73
- privileges  1     14.16 1166.6 119.82
- advance     1     71.27 1223.7 121.25
<none>                     1152.4 121.45
+ critical    1      3.41 1149.0 123.36
- learning    1    177.74 1330.1 123.75
- complaints  1    724.70 1877.1 134.09

Step:  AIC=119.73
rating ~ complaints + privileges + learning + advance

            Df Sum of Sq    RSS    AIC
- privileges  1     16.10 1179.1 118.14
- advance     1     61.60 1224.6 119.28
<none>                     1163.0 119.73
+ raises      1     10.61 1152.4 121.45
+ critical    1      7.21 1155.8 121.54
- learning    1    197.03 1360.0 122.42
- complaints  1   1165.94 2328.9 138.56

Step:  AIC=118.14
rating ~ complaints + learning + advance

            Df Sum of Sq    RSS    AIC
- advance     1     75.54 1254.7 118.00
<none>                     1179.1 118.14
+ privileges  1     16.10 1163.0 119.73
+ raises      1     12.54 1166.6 119.82
+ critical    1      7.18 1171.9 119.96
- learning    1    186.12 1365.2 120.54
- complaints  1   1259.91 2439.0 137.94

Step:  AIC=118
rating ~ complaints + learning

            Df Sum of Sq    RSS    AIC
<none>                     1254.7 118.00
```

```
+ advance     1      75.54 1179.1 118.14
- learning    1     114.73 1369.4 118.63
+ privileges  1      30.03 1224.6 119.28
+ raises      1       1.19 1253.5 119.97
+ critical    1       0.00 1254.7 120.00
- complaints  1    1370.91 2625.6 138.16


Call:
lm(formula = rating ~ complaints + learning, data = data)


Coefficients:
(Intercept)     complaints      learning
     9.8709         0.6435        0.2112
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = rating ~ complaints + learning, data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de `shapiro` nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.94486, p-value = 0.123
```

p-value = 0.0123 ¡=¿ p-value maior que 0.05 =¿ não rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo é distribuido normalmente.

1.8 Hipótese de ciclos-de-economia salarial (normal)

- **Modelar `sr`, a partir das outra variáveis**

- Hipótese formulada por Franco Modigliani 1960-1970, de que essas (outras) variáveis eram explicativas do fenômeno 'sr'.

1.8.1 Sobre o `Conjunto`

- Dados:
  - Sr: valor agregado à economia particular (razão entre valor total de economias pessoais e salário líquido)
  - Pop15: população sob quinze anos de idade.
  - Pop75: população acima de setenta e cinco anos de idade.
  - dpi: valor de salário líquido per-capita médio.
  - ddpi: taxa de crescimento de dpi.

1.8.2 Como utilizar pelo R

O `conjunto de dados` se encontra sob o pacote `datasets`. Desta forma, precisamos instalá-lo.

```
install.packages("datasets",mirror="https://vps.fmvz.usp.br/CRAN/")
```

Após instalação, precisamos invocar o pacote,

```
library(datasets)
```

Finalmente, podemos acessar o `conjunto`,

```
data <- data("LifeCycleSavings")
head(data)
```

1.8.3 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto savings.csv da seguinte maneira.

```
data <- read.csv('./data/csv/savings.csv')
head(data,5)
```

```
            sr    pop15 pop75 dpi     ddpi
Australia 11.43 29.35 2.87  2329.68 2.87
Austria   12.07 23.32 4.41  1507.99 3.93
Belgium   13.17 23.80 4.43  2108.47 3.82
Bolivia    5.75 41.89 1.67   189.13 0.22
Brazil    12.88 42.19 0.83   728.47 4.56
```

1.8.4   Regressão e Teste de Shapiro (normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```r
modreg_trein <- lm(sr ~ . , data)
summary(modreg_trein)
```

```
Call:
lm(formula = sr ~ ., data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-8.2422 -2.6857 -0.2488  2.4280  9.7509

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 28.5660865  7.3545161   3.884 0.000334 ***
pop15       -0.4611931  0.1446422  -3.189 0.002603 **
pop75       -1.6914977  1.0835989  -1.561 0.125530
dpi         -0.0003369  0.0009311  -0.362 0.719173
ddpi         0.4096949  0.1961971   2.088 0.042471 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.803 on 45 degrees of freedom
Multiple R-squared:  0.3385,Adjusted R-squared:  0.2797
F-statistic: 5.756 on 4 and 45 DF,  p-value: 0.0007904
```

2. StepAIC

```r
library(MASS)
```

```r
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=138.3
sr ~ pop15 + pop75 + dpi + ddpi

        Df Sum of Sq    RSS    AIC
- dpi    1      1.893 652.61 136.45
<none>               650.71 138.30
- pop75  1     35.236 685.95 138.94
- ddpi   1     63.054 713.77 140.93
- pop15  1    147.012 797.72 146.49


Step:  AIC=136.45
sr ~ pop15 + pop75 + ddpi

        Df Sum of Sq    RSS    AIC
<none>               652.61 136.45
- pop75  1     47.946 700.55 137.99
+ dpi    1      1.893 650.71 138.30
- ddpi   1     73.562 726.17 139.79
- pop15  1    145.789 798.40 144.53


Call:
lm(formula = sr ~ pop15 + pop75 + ddpi, data = data)


Coefficients:
(Intercept)          pop15          pop75           ddpi
    28.1247        -0.4518        -1.8354         0.4278
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = sr ~ pop15 + pop75 + ddpi, data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de `shapiro` nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test
```

```
data:  modreg_trein_AIC$residuals
W = 0.98764, p-value = 0.8765
```

p-value = 0.8765 ¡=¿ p-value maior que 0.05 =¿ não rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo é distribuido normalmente.

1.9 Preço de Computadores 1993-1995 (não normal)

- **Modelar preço (`price`) a partir das variáveis**.

1.9.1 Dados sobre o `Conjunto`

- Dados:

  - Speed: velocidade de rotação em MHz do processador (clock speed)
  - HD: tamanho da memória do disco rígido em MB
  - RAM: tamanho da RAM em MB
  - Screen: tamanho da tela em polegadas
  - CD: tem ou não entrada para CDs.
  - Multi: kit multimídia incluso ou não (caixa de som etc).
  - Premium: manufatura feita por compania conhecida (IBM etc).
  - Ads: quantidade de anúncio do computador por mês.
  - Trend: quanto tempo está no mercado.

1.9.2 Como utilizar pelo R

O `conjunto de dados` se encontra sob o pacote `Ecdat`. Desta forma, precisamos instalá-lo.

```
install.packages("Ecdat",mirror="https://vps.fmvz.usp.br/CRAN/")
```

Após instalação, precisamos invocar o pacote,

```
library(Ecdat)
```

Finalmente, podemos acessar o `conjunto`,

```
data <- data("Computers")
head(data)
```

1.9.3 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto computers.csv da seguinte maneira.

```
data <- read.csv('./data/csv/computers.csv')
head(data,5)
```

```
  price speed  hd  ram screen cd multi premium ads trend
1 1499  25     80   4  14     no no    yes     94  1
2 1795  33     85   2  14     no no    yes     94  1
3 1595  25    170   4  15     no no    yes     94  1
4 1849  25    170   8  14     no no    no      94  1
5 3295  33    340  16  14     no no    yes     94  1
```

1.9.4 Regressão e Teste de Shapiro (não normal)

1. Transformar variaveis categoricas

```
categoricalToNumeric <- function(data,...) {
  cols <- c(...)
  data[cols] <- lapply(data[cols], function(x) as.numeric(as.factor(x)))
  summary(data)
}
```

```
categoricalToNumeric(data,'screen', 'cd', 'multi', 'premium')
```

2. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```
modreg_trein <- lm(price ~ . , data)
summary(modreg_trein)
```

```
Call:
lm(formula = price ~ ., data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-1093.77 -174.24  -11.49  146.49 2001.05

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  307.98798   60.35341    5.103 3.44e-07 ***
speed          9.32028    0.18506   50.364  < 2e-16 ***
hd             0.78178    0.02761   28.311  < 2e-16 ***
ram           48.25596    1.06608   45.265  < 2e-16 ***
screen       123.08904    3.99950   30.776  < 2e-16 ***
cdyes         60.91671    9.51559    6.402 1.65e-10 ***
multiyes     104.32382   11.41268    9.141  < 2e-16 ***
premiumyes  -509.22473   12.34225  -41.259  < 2e-16 ***
ads            0.65729    0.05132   12.809  < 2e-16 ***
trend        -51.84958    0.62871  -82.470  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 275.3 on 6249 degrees of freedom
Multiple R-squared:  0.7756,Adjusted R-squared:  0.7752
F-statistic:  2399 on 9 and 6249 DF,  p-value: < 2.2e-16
```

3. StepAIC

```
library(MASS)
```

43

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=70336.65
price ~ speed + hd + ram + screen + cd + multi + premium + ads +
    trend

          Df Sum of Sq       RSS   AIC
<none>                 473783875 70337
- cd       1    3107211 476891087 70376
- multi    1    6335218 480119093 70418
- ads      1   12439298 486223174 70497
- hd       1   60768013 534551889 71090
- screen   1   71812147 545596023 71218
- premium  1  129062420 602846296 71843
- ram      1  155342777 629126653 72110
- speed    1  192316497 666100373 72467
- trend    1  515661043 989444918 74944

Call:
lm(formula = price ~ speed + hd + ram + screen + cd + multi +
    premium + ads + trend, data = data)

Coefficients:
(Intercept)         speed            hd           ram        screen         cdyes
   307.9880        9.3203        0.7818       48.2560      123.0890       60.9167
    multiyes    premiumyes           ads         trend
    104.3238     -509.2247        0.6573      -51.8496
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = price ~ speed + hd + ram + screen + cd + mult  +
    premium + ads + trend, data = data)
```

4. Teste de Shapiro Finalmente, aplicar o teste de shapiro nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals[1:5000])
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals[1:5000]
W = 0.95749, p-value < 2.2e-16
```

p-value ¡ 2.2e-16 ¡=¿ p-value muito menor que 0.05 =¿ rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo não é distribuido normalmente.

1.10   Peso ao Nascimento (normal)

- **Modelar peso ao nascimento (libras) (`Birthweight`) a partir das variáveis.**

1.10.1   Dados sobre o `Conjunto`

- Dados:

    - lowbwt: baixo peso ao nascer.
    - ID: Identificador
    - mage35: mãe mais velha do que 35 anos.
    - fnocig: número de cigarros fumado pelo pai diariamente.
    - fheight: peso do pai (kg)
    - fedyrs: quantidade de anos de educação do pai
    - fage: idade do pai
    - mppwt: peso da mãe pré gravidez.
    - mheight: tamanho da mãe (cm).
    - mnocig: número de cigarros fumados diariamente pela mãe.
    - Motherage: idade da mãe.
    - Gestation Smoker: fumante durante gestação
    - headcirumfer: circunferência da cabeça
    - length: tamanho (cm)

45

1.10.2   Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto Birth Weight da seguinte maneira.

```
data <- read.csv('./data/csv/Birthweight_reduced_kg_R.csv')
head(data,5)
```

```
  X...ID Length Birthweight Headcirc Gestation smoker mage mnocig mheight mppwt
1   1360     56        4.55       34        44      0   20      0     162    57
2   1016     53        4.32       36        40      0   19      0     171    62
3    462     58        4.10       39        41      0   35      0     172    58
4   1187     53        4.07       38        44      0   20      0     174    68
5    553     54        3.94       37        42      0   24      0     175    66
  fage fedyrs fnocig fheight lowbwt mage35
1   23     10     35     179      0      0
2   19     12      0     183      0      0
3   31     16     25     185      0      1
4   26     14     25     189      0      0
5   30     12      0     184      0      0
```

1.10.3   Regressão e Teste de Shapiro (normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```
modreg_trein <- lm(Birthweight ~ . , data)
summary(modreg_trein)
```

```
Call:
lm(formula = Birthweight ~ ., data = data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.47678 -0.20907 -0.02438  0.20960  0.60017

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
```

```
(Intercept) -3.830e+00  2.169e+00  -1.766  0.08916 .
X...ID      -6.808e-05  1.394e-04  -0.488  0.62931
Length       5.171e-02  3.888e-02   1.330  0.19503
Headcirc     8.688e-02  2.997e-02   2.899  0.00751 **
Gestation    9.189e-02  3.219e-02   2.855  0.00834 **
smoker      -2.320e-01  1.738e-01  -1.335  0.19353
mage         1.746e-02  2.904e-02   0.601  0.55293
mnocig       2.143e-03  7.078e-03   0.303  0.76442
mheight      1.366e-03  1.473e-02   0.093  0.92680
mppwt        9.371e-03  1.156e-02   0.811  0.42498
fage        -1.079e-02  1.977e-02  -0.546  0.58985
fedyrs      -3.636e-03  3.185e-02  -0.114  0.90998
fnocig       2.041e-03  4.311e-03   0.473  0.63991
fheight     -1.543e-02  9.951e-03  -1.550  0.13317
lowbwt      -1.612e-02  2.558e-01  -0.063  0.95023
mage35      -5.557e-01  3.669e-01  -1.515  0.14194
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3349 on 26 degrees of freedom
Multiple R-squared:  0.805, Adjusted R-squared:  0.6925
F-statistic: 7.156 on 15 and 26 DF,  p-value: 7.497e-06
```

2. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=-80.04
Birthweight ~ X...ID + Length + Headcirc + Gestation + smoker +
    mage + mnocig + mheight + mppwt + fage + fedyrs + fnocig +
    fheight + lowbwt + mage35


          Df Sum of Sq    RSS      AIC
- lowbwt   1   0.00045 2.9160 -82.033
```

```
- mheight    1    0.00096 2.9166 -82.025
- fedyrs     1    0.00146 2.9171 -82.018
- mnocig     1    0.01028 2.9259 -81.891
- fnocig     1    0.02513 2.9407 -81.679
- X...ID     1    0.02676 2.9423 -81.655
- fage       1    0.03341 2.9490 -81.561
- mage       1    0.04053 2.9561 -81.459
- mppwt      1    0.07368 2.9893 -80.991
<none>                    2.9156 -80.039
- Length     1    0.19840 3.1140 -79.274
- smoker     1    0.19978 3.1154 -79.256
- mage35     1    0.25725 3.1728 -78.488
- fheight    1    0.26951 3.1851 -78.326
- Gestation  1    0.91410 3.8297 -70.585
- Headcirc   1    0.94251 3.8581 -70.275

Step:  AIC=-82.03
Birthweight ~ X...ID + Length + Headcirc + Gestation + smoker +
    mage + mnocig + mheight + mppwt + fage + fedyrs + fnocig +
    fheight + mage35

            Df Sum of Sq    RSS     AIC
- mheight    1    0.00075 2.9168 -84.022
- fedyrs     1    0.00143 2.9175 -84.012
- mnocig     1    0.01182 2.9279 -83.863
- fnocig     1    0.02542 2.9415 -83.668
- X...ID     1    0.02842 2.9445 -83.625
- fage       1    0.03396 2.9500 -83.546
- mage       1    0.04337 2.9594 -83.413
- mppwt      1    0.08027 2.9963 -82.892
<none>                    2.9160 -82.033
- smoker     1    0.21097 3.1270 -81.099
- Length     1    0.25810 3.1741 -80.471
- fheight    1    0.28692 3.2030 -80.091
+ lowbwt     1    0.00045 2.9156 -80.039
- mage35     1    0.31943 3.2355 -79.667
- Headcirc   1    0.95078 3.8668 -72.180
- Gestation  1    0.95523 3.8713 -72.132

Step:  AIC=-84.02
```

```
Birthweight ~ X...ID + Length + Headcirc + Gestation + smoker +
    mage + mnocig + mppwt + fage + fedyrs + fnocig + fheight +
    mage35

          Df Sum of Sq    RSS      AIC
- fedyrs   1    0.00180 2.9186 -85.996
- mnocig   1    0.01321 2.9300 -85.832
- fnocig   1    0.02471 2.9415 -85.668
- X...ID   1    0.03082 2.9476 -85.580
- fage     1    0.04532 2.9621 -85.374
- mage     1    0.04921 2.9660 -85.319
<none>                   2.9168 -84.022
- mppwt    1    0.15874 3.0755 -83.796
- smoker   1    0.21100 3.1278 -83.088
- fheight  1    0.29026 3.2070 -82.037
+ mheight  1    0.00075 2.9160 -82.033
+ lowbwt   1    0.00023 2.9166 -82.025
- Length   1    0.31002 3.2268 -81.779
- mage35   1    0.32964 3.2464 -81.525
- Gestation 1   1.00467 3.9215 -73.591
- Headcirc 1    1.01254 3.9293 -73.507

Step:  AIC=-86
Birthweight ~ X...ID + Length + Headcirc + Gestation + smoker +
    mage + mnocig + mppwt + fage + fnocig + fheight + mage35

          Df Sum of Sq    RSS      AIC
- mnocig   1    0.01179 2.9304 -87.827
- X...ID   1    0.03449 2.9531 -87.502
- fnocig   1    0.03474 2.9533 -87.499
- fage     1    0.04466 2.9632 -87.358
- mage     1    0.04776 2.9663 -87.314
<none>                   2.9186 -85.996
- mppwt    1    0.15814 3.0767 -85.780
- smoker   1    0.20920 3.1278 -85.088
+ fedyrs   1    0.00180 2.9168 -84.022
+ mheight  1    0.00112 2.9175 -84.012
+ lowbwt   1    0.00017 2.9184 -83.998
- Length   1    0.31615 3.2347 -83.676
- fheight  1    0.31819 3.2368 -83.650
```

49

```
- mage35     1    0.32792 3.2465 -83.524
- Gestation  1    1.00289 3.9215 -75.590
- Headcirc   1    1.01344 3.9320 -75.478

Step:  AIC=-87.83
Birthweight ~ X...ID + Length + Headcirc + Gestation + smoker +
    mage + mppwt + fage + fnocig + fheight + mage35


            Df Sum of Sq    RSS      AIC
- X...ID     1    0.03286 2.9632 -89.358
- fnocig     1    0.03512 2.9655 -89.326
- fage       1    0.04919 2.9796 -89.127
- mage       1    0.05435 2.9847 -89.055
<none>                     2.9304 -87.827
- mppwt      1    0.17775 3.1081 -87.353
- smoker     1    0.27581 3.2062 -86.049
+ mnocig     1    0.01179 2.9186 -85.996
+ mheight    1    0.00232 2.9281 -85.860
+ lowbwt     1    0.00119 2.9292 -85.844
+ fedyrs     1    0.00038 2.9300 -85.832
- Length     1    0.30965 3.2400 -85.608
- mage35     1    0.32139 3.2518 -85.456
- fheight    1    0.33264 3.2630 -85.311
- Headcirc   1    1.00248 3.9329 -77.469
- Gestation  1    1.08456 4.0149 -76.601

Step:  AIC=-89.36
Birthweight ~ Length + Headcirc + Gestation + smoker + mage +
    mppwt + fage + fnocig + fheight + mage35


            Df Sum of Sq    RSS      AIC
- fage       1    0.03185 2.9951 -90.909
- mage       1    0.03474 2.9980 -90.869
- fnocig     1    0.04184 3.0051 -90.769
<none>                     2.9632 -89.358
- mppwt      1    0.19808 3.1613 -88.641
- smoker     1    0.25291 3.2161 -87.918
+ X...ID     1    0.03286 2.9304 -87.827
- Length     1    0.27680 3.2400 -87.608
+ mnocig     1    0.01015 2.9531 -87.502
```

```
+ mheight    1    0.00653 2.9567 -87.451
- mage35     1    0.29055 3.2538 -87.430
+ lowbwt     1    0.00271 2.9605 -87.397
+ fedyrs     1    0.00266 2.9606 -87.396
- fheight    1    0.32404 3.2873 -87.000
- Headcirc   1    1.10049 4.0637 -78.094
- Gestation  1    1.11010 4.0733 -77.995

Step:  AIC=-90.91
Birthweight ~ Length + Headcirc + Gestation + smoker + mage +
    mppwt + fnocig + fheight + mage35


           Df Sum of Sq    RSS     AIC
- mage      1    0.00479 2.9999 -92.842
- fnocig    1    0.03316 3.0283 -92.447
<none>                   2.9951 -90.909
- mppwt     1    0.20782 3.2029 -90.092
+ fage      1    0.03185 2.9632 -89.358
- mage35    1    0.27044 3.2655 -89.278
+ mheight   1    0.01967 2.9754 -89.186
- Length    1    0.28104 3.2761 -89.142
+ X...ID    1    0.01552 2.9796 -89.127
+ mnocig    1    0.01411 2.9810 -89.108
- smoker    1    0.28593 3.2810 -89.080
- fheight   1    0.29391 3.2890 -88.978
+ lowbwt    1    0.00210 2.9930 -88.939
+ fedyrs    1    0.00099 2.9941 -88.923
- Gestation 1    1.08113 4.0762 -79.965
- Headcirc  1    1.08377 4.0789 -79.938

Step:  AIC=-92.84
Birthweight ~ Length + Headcirc + Gestation + smoker + mppwt +
    fnocig + fheight + mage35


           Df Sum of Sq    RSS     AIC
- fnocig    1    0.04110 3.0410 -94.271
<none>                   2.9999 -92.842
- mppwt     1    0.24205 3.2419 -91.583
- Length    1    0.27708 3.2770 -91.132
- smoker    1    0.28184 3.2817 -91.071
```

51

```
+ mnocig     1    0.01556 2.9843 -91.060
+ mheight    1    0.01466 2.9852 -91.048
+ X...ID     1    0.01286 2.9870 -91.022
+ mage       1    0.00479 2.9951 -90.909
+ lowbwt     1    0.00413 2.9958 -90.900
+ fage       1    0.00191 2.9980 -90.869
+ fedyrs     1    0.00001 2.9999 -90.842
- fheight    1    0.32021 3.3201 -90.582
- mage35     1    0.42322 3.4231 -89.299
- Gestation  1    1.10582 4.1057 -81.662
- Headcirc   1    1.15094 4.1508 -81.203

Step:  AIC=-94.27
Birthweight ~ Length + Headcirc + Gestation + smoker + mppwt +
    fheight + mage35

            Df Sum of Sq    RSS      AIC
<none>                    3.0410 -94.271
- smoker     1    0.24149 3.2825 -93.061
- mppwt      1    0.24976 3.2907 -92.955
+ fnocig     1    0.04110 2.9999 -92.842
- fheight    1    0.28072 3.3217 -92.562
+ X...ID     1    0.01742 3.0236 -92.512
+ mnocig     1    0.01619 3.0248 -92.495
+ mage       1    0.01273 3.0283 -92.447
+ mheight    1    0.00774 3.0332 -92.378
+ fedyrs     1    0.00281 3.0382 -92.309
+ lowbwt     1    0.00031 3.0407 -92.275
+ fage       1    0.00011 3.0409 -92.272
- Length     1    0.32176 3.3627 -92.046
- mage35     1    0.47313 3.5141 -90.197
- Gestation  1    1.06836 4.1093 -83.625
- Headcirc   1    1.15478 4.1958 -82.751

Call:
lm(formula = Birthweight ~ Length + Headcirc + Gestation + smoker +
    mppwt + fheight + mage35, data = data)

Coefficients:
(Intercept)       Length      Headcirc      Gestation       smoker        mppwt
```

-3.91717	0.05011	0.08611	0.08703	-0.16006	0.01198

```
   fheight       mage35
  -0.01274     -0.38636
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = Birthweight ~ Length + Headcirc + Gestation + smoker +
    mppwt + fheight + mage35, data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de `shapiro` nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.95885, p-value = 0.1343
```

p-value = 0.1343 ¡=¿ p-value maior que 0.05 =¿ não rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo é distribuido normalmente.

1.11 Crime (normal)

- **Modelar taxa de crime (`CrimeRate`) a partir das variáveis**.

1.11.1 Dados sobre o `Conjunto`

- Dados:

  - CrimeRate: Taxa de criminalidade (ofensas por milhão de habitantes).
  - Youth: Jovens entre 18-24 anos a cada mil habitantes.
  - Southern: Estado do sul?
  - Education: Tempo de educação (anos de estudo até 25)

- ExpenditureYear0: Dinheiro para segurança pública per capta.
- LabourForce: Quantidade de jovens trabalhadores por 1000 habitantes.
- Males: Homens (por cada 1000 mulheres).
- MoreMales: Mais homens que mulheres?.
- StateSize: Tamanho do estado em milhares.
- YouthUnemployment: Desemprego de jovens por mil.
- BelowWage: Número de famílias abaixo de meio salário por mil.
- Wage: Salário médio semanal.
- MatureUnemployment: Desemprego de sêniors (35-39) por mil.

1.11.2 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto Crimes da seguinte maneira.

```
data <- read.csv('./data/csv/Crime_R.csv')
head(data,5)
```

	X...CrimeRate	Youth	Southern	Education	ExpenditureYear0	LabourForce	Males
1	45.5	135	0	12.4	69	540	965
2	52.3	140	0	10.9	55	535	1045
3	56.6	157	1	11.2	47	512	962
4	60.3	139	1	11.9	46	480	968
5	64.2	126	0	12.2	106	599	989

	MoreMales	StateSize	YouthUnemployment	...	ExpenditureYear10	LabourForce10
1	0	6	80	...	71	564
2	1	6	135	...	54	540
3	0	22	97	...	44	529
4	0	19	135	...	41	497
5	0	40	78	...	97	602

	Males10	MoreMales10	StateSize10	YouthUnemploy10	MatureUnemploy10
1	974	0	6	82	20
2	1039	1	7	138	39
3	959	0	24	98	33
4	983	0	20	131	50
5	989	0	42	79	24

```
   HighYouthUnemploy10 Wage10 BelowWage10
1 1                    632    142
2 1                    521    210
3 0                    359    256
4 0                    510    235
5 1                    660    162
```

1.11.3 Regressão e Teste de Shapiro (normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas, vamos aplicar a regressão linear múltipla,

```
modreg_trein <- lm(X...CrimeRate ~ . , data)
summary(modreg_trein)
```

```
Call:
lm(formula = X...CrimeRate ~ ., data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-3.7169 -0.8068  0.1067  0.7969  2.7024

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)        31.179959  24.586183   1.268   0.2193
Youth              -0.047450   0.062098  -0.764   0.4537
Southern           -1.750704   1.475258  -1.187   0.2492
Education           1.450580   3.253357   0.446   0.6605
ExpenditureYear0    0.337407   0.119796   2.817   0.0107 *
LabourForce        -0.020361   0.041917  -0.486   0.6324
Males              -0.064828   0.036138  -1.794   0.0880 .
MoreMales           0.823135   3.192155   0.258   0.7991
StateSize          -0.197694   0.334701  -0.591   0.5614
YouthUnemployment  -0.114566   0.194817  -0.588   0.5631
MatureUnemployment -0.399896   0.239421  -1.670   0.1104
HighYouthUnemploy   0.597149   1.562191   0.382   0.7063
Wage               -0.006439   0.026973  -0.239   0.8137
BelowWage           0.036793   0.046376   0.793   0.4369
```

```
CrimeRate10          0.734102   0.013667  53.715   <2e-16 ***
Youth10              0.010987   0.060690   0.181   0.8582
Education10         -1.470504   3.075265  -0.478   0.6377
ExpenditureYear10   -0.300559   0.129053  -2.329   0.0305 *
LabourForce10        0.034297   0.047031   0.729   0.4743
Males10              0.057152   0.028958   1.974   0.0624 .
MoreMales10         -3.121975   2.717061  -1.149   0.2641
StateSize10          0.158700   0.324051   0.490   0.6296
YouthUnemploy10      0.117936   0.189152   0.624   0.5400
MatureUnemploy10     0.448407   0.214681   2.089   0.0497 *
HighYouthUnemploy10  0.342417   1.230333   0.278   0.7836
Wage10              -0.003951   0.025435  -0.155   0.8781
BelowWage10         -0.023423   0.044681  -0.524   0.6059
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.923 on 20 degrees of freedom
Multiple R-squared:  0.9981,Adjusted R-squared:  0.9956
F-statistic: 398.5 on 26 and 20 DF,  p-value: < 2.2e-16
```

2. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein, direction="both", keep=NULL)
```

```
Start:  AIC=75.33
X...CrimeRate ~ Youth + Southern + Education + ExpenditureYear0 +
    LabourForce + Males + MoreMales + StateSize + YouthUnemployment +
    MatureUnemployment + HighYouthUnemploy + Wage + BelowWage +
    CrimeRate10 + Youth10 + Education10 + ExpenditureYear10 +
    LabourForce10 + Males10 + MoreMales10 + StateSize10 + YouthUnemploy10 +
    MatureUnemploy10 + HighYouthUnemploy10 + Wage10 + BelowWage10

                 Df Sum of Sq    RSS     AIC
- Wage10          1       0.1   74.1  73.384
```

```
- Youth10                  1        0.1    74.1  73.404
- Wage                     1        0.2    74.2  73.461
- MoreMales                1        0.2    74.2  73.483
- HighYouthUnemploy10      1        0.3    74.3  73.509
- HighYouthUnemploy        1        0.5    74.5  73.669
- Education                1        0.7    74.7  73.792
- Education10              1        0.8    74.8  73.861
- LabourForce              1        0.9    74.9  73.878
- StateSize10              1        0.9    74.9  73.887
- BelowWage10              1        1.0    75.0  73.968
- YouthUnemployment        1        1.3    75.3  74.133
- StateSize               1        1.3    75.3  74.140
- YouthUnemploy10          1        1.4    75.4  74.232
- LabourForce10            1        2.0    76.0  74.560
- Youth                    1        2.2    76.1  74.679
- BelowWage                1        2.3    76.3  74.783
<none>                                     74.0  75.327
- MoreMales10              1        4.9    78.9  76.331
- Southern                 1        5.2    79.2  76.525
- MatureUnemployment       1       10.3    84.3  79.464
- Males                    1       11.9    85.9  80.339
- Males10                  1       14.4    88.4  81.690
- MatureUnemploy10         1       16.1    90.1  82.601
- ExpenditureYear10        1       20.1    94.1  84.605
- ExpenditureYear0         1       29.3   103.3  89.028
- CrimeRate10              1    10674.0 10748.0 307.320

Step:  AIC=73.38
X...CrimeRate ~ Youth + Southern + Education + ExpenditureYear0 +
    LabourForce + Males + MoreMales + StateSize + YouthUnemployment +
    MatureUnemployment + HighYouthUnemploy + Wage + BelowWage +
    CrimeRate10 + Youth10 + Education10 + ExpenditureYear10 +
    LabourForce10 + Males10 + MoreMales10 + StateSize10 + YouthUnemploy10 +
    MatureUnemploy10 + HighYouthUnemploy10 + BelowWage10

                      Df Sum of Sq    RSS     AIC
- Youth10                  1        0.2    74.2  71.492
- HighYouthUnemploy10      1        0.2    74.3  71.509
- MoreMales                1        0.3    74.3  71.544
- Education                1        0.6    74.7  71.792
```

57

```
- Education10            1      0.8    74.8   71.862
- HighYouthUnemploy      1      0.8    74.9   71.884
- LabourForce            1      0.8    74.9   71.899
- StateSize10            1      1.2    75.3   72.124
- YouthUnemployment      1      1.2    75.3   72.137
- BelowWage10            1      1.3    75.4   72.230
- YouthUnemploy10        1      1.4    75.5   72.247
- StateSize              1      1.7    75.7   72.421
- LabourForce10          1      1.9    76.0   72.598
- Youth                  1      2.6    76.7   73.006
- BelowWage              1      3.0    77.1   73.277
<none>                                 74.1   73.384
- Wage                   1      3.2    77.3   73.396
- MoreMales10            1      5.0    79.1   74.470
- Southern               1      5.1    79.2   74.526
+ Wage10                 1      0.1    74.0   75.327
- MatureUnemployment     1     10.6    84.7   77.675
- Males                  1     11.8    85.9   78.348
- Males10                1     14.4    88.5   79.718
- MatureUnemploy10       1     16.2    90.3   80.696
- ExpenditureYear10      1     22.1    96.1   83.641
- ExpenditureYear0       1     32.1   106.2   88.302
- CrimeRate10            1  10720.0 10794.1  305.521

Step:  AIC=71.49
X...CrimeRate ~ Youth + Southern + Education + ExpenditureYear0 +
    LabourForce + Males + MoreMales + StateSize + YouthUnemployment +
    MatureUnemployment + HighYouthUnemploy + Wage + BelowWage +
    CrimeRate10 + Education10 + ExpenditureYear10 + LabourForce10 +
    Males10 + MoreMales10 + StateSize10 + YouthUnemploy10 + MatureUnemploy10 +
    HighYouthUnemploy10 + BelowWage10

                         Df Sum of Sq      RSS      AIC
- MoreMales              1      0.2    74.5   69.639
- HighYouthUnemploy10    1      0.2    74.5   69.647
- HighYouthUnemploy      1      0.7    74.9   69.907
- Education              1      0.7    74.9   69.910
- Education10            1      0.8    75.0   69.996
- LabourForce            1      0.8    75.1   70.026
- StateSize10            1      1.0    75.3   70.133
```

```
- YouthUnemployment     1        1.4     75.6   70.370
- StateSize             1        1.5     75.7   70.423
- YouthUnemploy10       1        1.7     75.9   70.534
- BelowWage10           1        2.0     76.3   70.770
- LabourForce10         1        2.1     76.3   70.785
- Youth                 1        2.7     76.9   71.159
<none>                                   74.2   71.492
- Wage                  1        3.5     77.8   71.682
- BelowWage             1        3.8     78.1   71.839
- MoreMales10           1        5.0     79.2   72.542
- Southern              1        5.0     79.3   72.562
+ Youth10               1        0.2     74.1   73.384
+ Wage10                1        0.1     74.1   73.404
- MatureUnemployment    1       11.0     85.3   75.995
- Males                 1       12.8     87.1   76.987
- Males10               1       16.1     90.4   78.740
- MatureUnemploy10      1       16.6     90.9   78.995
- ExpenditureYear10     1       22.2     96.5   81.806
- ExpenditureYear0      1       32.3    106.6   86.486
- CrimeRate10           1    10889.2  10963.4  304.252

Step:  AIC=69.64
X...CrimeRate ~ Youth + Southern + Education + ExpenditureYear0 +
    LabourForce + Males + StateSize + YouthUnemployment + MatureUnemployment +
    HighYouthUnemploy + Wage + BelowWage + CrimeRate10 + Education10 +
    ExpenditureYear10 + LabourForce10 + Males10 + MoreMales10 +
    StateSize10 + YouthUnemploy10 + MatureUnemploy10 + HighYouthUnemploy10 +
    BelowWage10

                       Df Sum of Sq    RSS      AIC
- HighYouthUnemploy10   1        0.3     74.8   67.809
- LabourForce           1        0.8     75.3   68.143
- HighYouthUnemploy     1        0.9     75.3   68.180
- Education             1        0.9     75.4   68.219
- Education10           1        1.1     75.6   68.324
- YouthUnemployment     1        1.2     75.7   68.405
- StateSize10           1        1.4     75.8   68.486
- YouthUnemploy10       1        1.4     75.9   68.544
- StateSize             1        1.9     76.4   68.818
- BelowWage10           1        1.9     76.4   68.821
```

```
- LabourForce10          1         2.0     76.5    68.868
- Youth                  1         2.5     77.0    69.175
<none>                                     74.5    69.639
- Wage                   1         3.5     78.0    69.823
- BelowWage              1         3.6     78.1    69.872
- Southern               1         6.1     80.6    71.344
+ MoreMales              1         0.2     74.2    71.492
+ Youth10                1         0.2     74.3    71.544
+ Wage10                 1         0.1     74.3    71.549
- MoreMales10            1         9.9     84.4    73.493
- MatureUnemployment     1        11.0     85.5    74.103
- Males10                1        16.5     91.0    77.049
- Males                  1        16.6     91.1    77.085
- MatureUnemploy10       1        17.3     91.8    77.440
- ExpenditureYear10      1        22.1     96.6    79.853
- ExpenditureYear0       1        32.5    107.0    84.674
- CrimeRate10            1     10995.2  11069.7   302.705

Step:  AIC=67.81
X...CrimeRate ~ Youth + Southern + Education + ExpenditureYear0 +
    LabourForce + Males + StateSize + YouthUnemployment + MatureUnemployment +
    HighYouthUnemploy + Wage + BelowWage + CrimeRate10 + Education10 +
    ExpenditureYear10 + LabourForce10 + Males10 + MoreMales10 +
    StateSize10 + YouthUnemploy10 + MatureUnemploy10 + BelowWage10


                        Df Sum of Sq     RSS      AIC
- Education              1         0.9     75.7    66.398
- LabourForce            1         1.1     75.8    66.482
- Education10            1         1.2     75.9    66.528
- YouthUnemployment      1         1.3     76.0    66.600
- StateSize10            1         1.5     76.3    66.756
- YouthUnemploy10        1         1.6     76.3    66.801
- HighYouthUnemploy      1         1.8     76.6    66.933
- StateSize              1         2.1     76.8    67.093
- LabourForce10          1         2.3     77.1    67.252
- BelowWage10            1         2.6     77.4    67.415
- Youth                  1         2.9     77.7    67.625
<none>                                     74.8    67.809
- Wage                   1         3.7     78.4    68.078
- BelowWage              1         4.5     79.2    68.554
```

```
- Southern                1        6.0      80.8    69.453
+ HighYouthUnemploy10     1        0.3      74.5    69.639
+ MoreMales               1        0.3      74.5    69.647
+ Youth10                 1        0.2      74.6    69.684
+ Wage10                  1        0.0      74.7    69.804
- MoreMales10             1       10.4      85.2    71.945
- MatureUnemployment      1       11.3      86.1    72.444
- Males                   1       16.3      91.1    75.095
- Males10                 1       16.7      91.5    75.286
- MatureUnemploy10        1       17.0      91.8    75.460
- ExpenditureYear10       1       21.9      96.6    77.873
- ExpenditureYear0        1       32.4     107.1    82.713
- CrimeRate10             1    11054.0   11128.7   300.955

Step:  AIC=66.4
X...CrimeRate ~ Youth + Southern + ExpenditureYear0 + LabourForce +
    Males + StateSize + YouthUnemployment + MatureUnemployment +
    HighYouthUnemploy + Wage + BelowWage + CrimeRate10 + Education10 +
    ExpenditureYear10 + LabourForce10 + Males10 + MoreMales10 +
    StateSize10 + YouthUnemploy10 + MatureUnemploy10 + BelowWage10


                       Df Sum of Sq     RSS      AIC
- Education10             1        0.5      76.2    64.683
- YouthUnemployment       1        0.9      76.6    64.969
- LabourForce             1        1.2      76.9    65.121
- YouthUnemploy10         1        1.3      77.0    65.205
- StateSize10             1        1.5      77.2    65.313
- HighYouthUnemploy       1        1.5      77.2    65.339
- StateSize               1        2.0      77.7    65.639
- LabourForce10           1        2.5      78.2    65.910
- Youth                   1        2.8      78.5    66.102
- BelowWage10             1        3.0      78.7    66.236
<none>                                     75.7    66.398
- Wage                    1        4.3      79.9    66.968
- BelowWage               1        4.9      80.6    67.330
+ Education               1        0.9      74.8    67.809
+ MoreMales               1        0.5      75.2    68.067
+ HighYouthUnemploy10     1        0.3      75.4    68.219
- Southern                1        6.5      82.2    68.248
+ Youth10                 1        0.2      75.5    68.267
```

```
+ Wage10                   1       0.1     75.6   68.365
- MoreMales10              1      11.4     87.1   71.010
- MatureUnemployment       1      13.5     89.2   72.124
- Males                    1      15.4     91.1   73.115
- Males10                  1      15.9     91.6   73.376
- MatureUnemploy10         1      18.7     94.4   74.779
- ExpenditureYear10        1      21.2     96.9   76.008
- ExpenditureYear0         1      32.0    107.7   80.979
- CrimeRate10              1   11081.5  11157.2  299.076

Step:  AIC=64.68
X...CrimeRate ~ Youth + Southern + ExpenditureYear0 + LabourForce +
    Males + StateSize + YouthUnemployment + MatureUnemployment +
    HighYouthUnemploy + Wage + BelowWage + CrimeRate10 + ExpenditureYear10 +
    LabourForce10 + Males10 + MoreMales10 + StateSize10 + YouthUnemploy10 +
    MatureUnemploy10 + BelowWage10

                          Df Sum of Sq     RSS      AIC
- LabourForce              1       0.9     77.1   63.234
- YouthUnemployment        1       0.9     77.1   63.258
- YouthUnemploy10          1       1.2     77.3   63.395
- HighYouthUnemploy        1       1.5     77.7   63.597
- StateSize10              1       1.7     77.9   63.728
- LabourForce10            1       2.0     78.2   63.929
- StateSize                1       2.3     78.5   64.080
- Youth                    1       2.4     78.5   64.122
- BelowWage10              1       2.6     78.7   64.249
<none>                                     76.2   64.683
- Wage                     1       4.1     80.2   65.124
- BelowWage                1       4.4     80.6   65.351
+ MoreMales                1       0.6     75.6   66.328
+ Education10              1       0.5     75.7   66.398
+ HighYouthUnemploy10      1       0.4     75.7   66.416
+ Youth10                  1       0.3     75.8   66.471
+ Education                1       0.3     75.9   66.528
+ Wage10                   1       0.1     76.1   66.630
- Southern                 1       7.9     84.1   67.343
- MoreMales10              1      12.2     88.4   69.665
- MatureUnemployment       1      13.1     89.3   70.160
- Males10                  1      15.5     91.6   71.379
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- Males                   1       15.7     91.9  71.512
- MatureUnemploy10        1       18.4     94.5  72.850
- ExpenditureYear10       1       25.0    101.2  76.027
- ExpenditureYear0        1       36.8    113.0  81.213
- CrimeRate10             1    12440.1 12516.3 302.478

Step:  AIC=63.23
X...CrimeRate ~ Youth + Southern + ExpenditureYear0 + Males +
    StateSize + YouthUnemployment + MatureUnemployment + HighYouthUnemploy +
    Wage + BelowWage + CrimeRate10 + ExpenditureYear10 + LabourForce10 +
    Males10 + MoreMales10 + StateSize10 + YouthUnemploy10 + MatureUnemploy10 +
    BelowWage10

                        Df Sum of Sq     RSS     AIC
- YouthUnemployment      1       0.9     78.0  61.784
- YouthUnemploy10        1       1.0     78.1  61.870
- HighYouthUnemploy      1       1.7     78.8  62.276
- Youth                  1       1.8     78.9  62.347
- StateSize10            1       1.9     78.9  62.375
- StateSize              1       2.5     79.6  62.737
- LabourForce10          1       2.6     79.7  62.799
- BelowWage10            1       3.0     80.1  63.031
<none>                                   77.1  63.234
- BelowWage              1       4.5     81.6  63.910
- Wage                   1       5.6     82.7  64.541
+ LabourForce            1       0.9     76.2  64.683
+ HighYouthUnemploy10    1       0.7     76.4  64.822
+ MoreMales              1       0.5     76.5  64.924
+ Youth10                1       0.4     76.7  65.010
+ Wage10                 1       0.2     76.8  65.096
+ Education10            1       0.2     76.9  65.121
+ Education              1       0.1     77.0  65.194
- Southern               1       8.9     86.0  66.385
- MatureUnemployment     1      12.5     89.5  68.274
- MoreMales10            1      12.9     89.9  68.487
- Males                  1      14.9     91.9  69.528
- Males10                1      14.9     91.9  69.540
- MatureUnemploy10       1      18.1     95.1  71.147
- ExpenditureYear10      1      24.1    101.2  74.029
- ExpenditureYear0       1      35.9    113.0  79.219

                          63
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- CrimeRate10          1    12524.2 12601.3 300.796

Step:  AIC=61.78
X...CrimeRate ~ Youth + Southern + ExpenditureYear0 + Males +
    StateSize + MatureUnemployment + HighYouthUnemploy + Wage +
    BelowWage + CrimeRate10 + ExpenditureYear10 + LabourForce10 +
    Males10 + MoreMales10 + StateSize10 + YouthUnemploy10 + MatureUnemploy10 +
    BelowWage10

                         Df Sum of Sq      RSS      AIC
- YouthUnemploy10         1       0.2     78.1   59.879
- Youth                   1       1.1     79.1   60.469
- HighYouthUnemploy       1       1.8     79.7   60.834
- StateSize10             1       1.8     79.8   60.872
- StateSize               1       2.4     80.3   61.195
- BelowWage10             1       2.6     80.6   61.354
- LabourForce10           1       3.1     81.0   61.592
<none>                                    78.0   61.784
- BelowWage               1       3.9     81.9   62.082
- Wage                    1       5.4     83.4   62.939
+ YouthUnemployment       1       0.9     77.1   63.234
+ LabourForce            1       0.9     77.1   63.258
+ HighYouthUnemploy10     1       0.7     77.2   63.346
+ Youth10                 1       0.6     77.4   63.423
+ Wage10                  1       0.3     77.6   63.593
+ MoreMales               1       0.2     77.8   63.661
+ Education10             1       0.2     77.8   63.666
+ Education               1       0.1     77.9   63.732
- Southern                1       8.5     86.4   64.626
- Males                   1      14.7     92.7   67.927
- MoreMales10             1      14.8     92.7   67.933
- Males10                 1      15.4     93.3   68.235
- MatureUnemployment      1      18.2     96.2   69.650
- MatureUnemploy10        1      22.5    100.5   71.716
- ExpenditureYear10       1      23.3    101.3   72.093
- ExpenditureYear0        1      35.5    113.5   77.425
- CrimeRate10             1    12530.1 12608.1 298.821

Step:  AIC=59.88
X...CrimeRate ~ Youth + Southern + ExpenditureYear0 + Males +
```

```
        StateSize + MatureUnemployment + HighYouthUnemploy + Wage +
        BelowWage + CrimeRate10 + ExpenditureYear10 + LabourForce10 +
        Males10 + MoreMales10 + StateSize10 + MatureUnemploy10 +
        BelowWage10

                           Df Sum of Sq      RSS      AIC
- Youth                     1       1.0     79.1   58.490
- StateSize10               1       2.1     80.2   59.117
- BelowWage10               1       2.5     80.6   59.376
- StateSize                 1       2.7     80.8   59.448
- LabourForce10             1       3.0     81.1   59.628
<none>                                      78.1   59.879
- HighYouthUnemploy         1       3.7     81.8   60.055
- BelowWage                 1       3.7     81.9   60.082
- Wage                      1       5.5     83.7   61.102
+ HighYouthUnemploy10       1       0.8     77.3   61.395
+ LabourForce              1       0.7     77.4   61.435
+ Youth10                   1       0.7     77.4   61.469
+ Wage10                    1       0.3     77.9   61.728
+ YouthUnemploy10           1       0.2     78.0   61.784
+ MoreMales                 1       0.1     78.0   61.807
+ Education10               1       0.1     78.0   61.835
+ Education                 1       0.0     78.1   61.870
+ YouthUnemployment         1       0.0     78.1   61.870
- Southern                  1       9.3     87.4   63.183
- MoreMales10               1      14.7     92.8   65.965
- Males10                   1      15.2     93.3   66.235
- Males                     1      15.6     93.7   66.449
- MatureUnemployment        1      18.7     96.8   67.969
- ExpenditureYear10         1      23.2    101.3   70.095
- MatureUnemploy10          1      23.7    101.8   70.340
- ExpenditureYear0          1      35.6    113.7   75.536
- CrimeRate10               1   12570.5  12648.6  296.972

Step:  AIC=58.49
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + HighYouthUnemploy + Wage + BelowWage +
    CrimeRate10 + ExpenditureYear10 + LabourForce10 + Males10 +
    MoreMales10 + StateSize10 + MatureUnemploy10 + BelowWage10
```

```
                       Df Sum of Sq      RSS      AIC
- StateSize10           1       2.6     81.7   58.004
- BelowWage10           1       2.7     81.9   58.083
- LabourForce10         1       3.1     82.2   58.301
- StateSize             1       3.2     82.4   58.368
<none>                                  79.1   58.490
- Wage                  1       4.5     83.7   59.109
- BelowWage             1       4.6     83.8   59.171
- HighYouthUnemploy     1       5.1     84.3   59.435
+ Youth                 1       1.0     78.1   59.879
+ HighYouthUnemploy10   1       1.0     78.2   59.920
+ LabourForce           1       0.4     78.8   60.258
+ Wage10                1       0.1     79.1   60.441
+ MoreMales             1       0.1     79.1   60.446
+ YouthUnemploy10       1       0.0     79.1   60.469
+ Education10           1       0.0     79.1   60.487
+ Education             1       0.0     79.1   60.487
+ YouthUnemployment     1       0.0     79.1   60.488
+ Youth10               1       0.0     79.1   60.489
- Southern              1      11.6     90.7   62.900
- MoreMales10           1      14.0     93.2   64.164
- Males10               1      14.2     93.4   64.259
- Males                 1      15.2     94.3   64.746
- MatureUnemployment    1      20.1     99.3   67.150
- ExpenditureYear10     1      22.7    101.9   68.359
- MatureUnemploy10      1      27.6    106.7   70.537
- ExpenditureYear0      1      35.5    114.7   73.923
- CrimeRate10           1   13906.3  13985.5  299.694

Step:  AIC=58
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + HighYouthUnemploy + Wage + BelowWage +
    CrimeRate10 + ExpenditureYear10 + LabourForce10 + Males10 +
    MoreMales10 + MatureUnemploy10 + BelowWage10

                       Df Sum of Sq      RSS      AIC
- LabourForce10         1       2.5     84.2   57.393
- BelowWage10           1       3.5     85.2   57.979
<none>                                  81.7   58.004
- HighYouthUnemploy     1       3.9     85.6   58.193
```

```
+ StateSize10              1        2.6      79.1   58.490
- BelowWage                1        4.9      86.6   58.725
+ HighYouthUnemploy10      1        1.6      80.1   59.085
+ Youth                    1        1.5      80.2   59.117
+ LabourForce              1        0.4      81.3   59.770
+ MoreMales                1        0.3      81.4   59.813
+ Youth10                  1        0.2      81.5   59.873
+ YouthUnemploy10          1        0.2      81.6   59.903
+ YouthUnemployment        1        0.1      81.6   59.947
- Wage                     1        7.2      89.0   59.996
+ Education                1        0.0      81.7   60.001
+ Education10              1        0.0      81.7   60.001
+ Wage10                   1        0.0      81.7   60.002
- Males10                  1       12.7      94.4   62.779
- Males                    1       12.9      94.6   62.875
- Southern                 1       13.2      94.9   63.017
- MoreMales10              1       13.5      95.2   63.181
- MatureUnemployment       1       17.6      99.3   65.155
- StateSize                1       20.9     102.6   66.702
- ExpenditureYear10        1       21.7     103.4   67.056
- MatureUnemploy10         1       25.6     107.3   68.815
- ExpenditureYear0         1       35.3     117.0   72.867
- CrimeRate10              1    14223.5   14305.2  298.757

Step:  AIC=57.39
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + HighYouthUnemploy + Wage + BelowWage +
    CrimeRate10 + ExpenditureYear10 + Males10 + MoreMales10 +
    MatureUnemploy10 + BelowWage10

                        Df Sum of Sq     RSS      AIC
- BelowWage10              1        3.4      87.6   57.252
- HighYouthUnemploy        1        3.6      87.8   57.379
<none>                                       84.2   57.393
+ LabourForce10            1        2.5      81.7   58.004
- BelowWage                1        5.4      89.5   58.293
+ StateSize10              1        1.9      82.2   58.301
+ LabourForce              1        1.6      82.6   58.474
+ Youth                    1        1.6      82.6   58.485
+ HighYouthUnemploy10      1        0.8      83.4   58.934
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```
- Wage                     1      7.2    91.4   59.250
+ MoreMales                1      0.2    84.0   59.275
+ Wage10                   1      0.2    84.0   59.305
+ Youth10                  1      0.1    84.1   59.322
+ Education               1      0.1    84.1   59.328
+ YouthUnemployment       1      0.1    84.1   59.332
+ Education10             1      0.1    84.1   59.364
+ YouthUnemploy10         1      0.0    84.1   59.370
- Males                    1     10.5    94.7   60.935
- Males10                  1     12.3    96.5   61.796
- MoreMales10              1     14.8    99.0   62.990
- StateSize                1     19.4   103.6   65.134
- Southern                 1     23.6   107.7   66.987
- ExpenditureYear10        1     25.5   109.7   67.835
- MatureUnemployment       1     28.6   112.7   69.119
- MatureUnemploy10         1     33.4   117.6   71.092
- ExpenditureYear0         1     40.0   124.2   73.656
- CrimeRate10              1  14667.9 14752.1  298.203

Step:  AIC=57.25
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + HighYouthUnemploy + Wage + BelowWage +
    CrimeRate10 + ExpenditureYear10 + Males10 + MoreMales10 +
    MatureUnemploy10


                      Df Sum of Sq     RSS      AIC
- BelowWage            1      2.0    89.5   56.293
- HighYouthUnemploy    1      2.9    90.4   56.759
<none>                               87.6   57.252
+ BelowWage10          1      3.4    84.2   57.393
+ StateSize10          1      2.6    85.0   57.828
+ LabourForce10        1      2.3    85.2   57.979
+ Youth                1      2.0    85.6   58.179
+ HighYouthUnemploy10  1      1.9    85.7   58.230
+ LabourForce          1      1.4    86.2   58.520
+ Education            1      1.2    86.4   58.596
+ Education10          1      1.0    86.6   58.731
- Wage                 1      7.0    94.6   58.865
+ Wage10               1      0.7    86.9   58.868
+ YouthUnemployment    1      0.2    87.4   59.150
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+ YouthUnemploy10        1        0.1      87.4   59.173
+ MoreMales              1        0.1      87.4   59.181
+ Youth10                1        0.0      87.6   59.251
- Males                  1       12.0      99.6   61.300
- Males10                1       14.3     101.9   62.372
- MoreMales10            1       16.8     104.4   63.489
- StateSize              1       23.4     110.9   66.362
- MatureUnemployment     1       28.1     115.6   68.315
- ExpenditureYear10      1       28.6     116.2   68.550
- Southern               1       29.1     116.7   68.735
- MatureUnemploy10       1       33.5     121.1   70.491
- ExpenditureYear0       1       43.5     131.0   74.188
- CrimeRate10            1    15110.9   15198.5  297.604

Step:  AIC=56.29
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + HighYouthUnemploy + Wage + CrimeRate10 +
    ExpenditureYear10 + Males10 + MoreMales10 + MatureUnemploy10


                       Df Sum of Sq      RSS      AIC
- HighYouthUnemploy      1        3.0      92.5   55.825
<none>                                     89.5   56.293
+ LabourForce10          1        2.9      86.6   56.749
+ Youth                  1        2.8      86.8   56.816
+ StateSize10            1        2.0      87.5   57.223
+ BelowWage              1        2.0      87.6   57.252
+ LabourForce            1        1.9      87.6   57.276
+ HighYouthUnemploy10    1        1.8      87.7   57.335
+ Wage10                 1        1.1      88.5   57.729
+ YouthUnemploy10        1        0.6      89.0   57.993
+ YouthUnemployment      1        0.5      89.0   58.018
+ Education              1        0.5      89.0   58.034
+ Education10            1        0.3      89.2   58.111
+ MoreMales              1        0.2      89.4   58.205
+ Youth10                1        0.0      89.5   58.271
+ BelowWage10            1        0.0      89.5   58.293
- Males                  1       14.1     103.6   61.156
- MoreMales10            1       16.1     105.6   62.067
- Males10                1       18.2     107.8   62.997
- StateSize              1       21.5     111.1   64.420
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- Wage                      1       25.3     114.9  65.998
- Southern                  1       28.9     118.4  67.440
- MatureUnemployment        1       29.8     119.4  67.811
- ExpenditureYear10         1       33.3     122.8  69.155
- MatureUnemploy10          1       35.7     125.2  70.059
- ExpenditureYear0          1       47.5     137.1  74.308
- CrimeRate10               1    17139.1   17228.7 301.497

Step:  AIC=55.82
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + Wage + CrimeRate10 + ExpenditureYear10 +
    Males10 + MoreMales10 + MatureUnemploy10

                        Df Sum of Sq     RSS     AIC
+ HighYouthUnemploy10   1         4.4    88.1  55.542
+ Youth                 1         4.0    88.5  55.729
<none>                                   92.5  55.825
+ HighYouthUnemploy     1         3.0    89.5  56.293
+ LabourForce10         1         2.7    89.8  56.450
+ BelowWage             1         2.1    90.4  56.759
+ LabourForce           1         1.9    90.6  56.864
+ Wage10                1         1.7    90.8  56.970
+ Education             1         1.2    91.3  57.216
+ StateSize10           1         1.0    91.5  57.296
+ Education10           1         1.0    91.5  57.315
+ Youth10               1         0.5    92.0  57.588
+ MoreMales             1         0.2    92.3  57.712
+ YouthUnemployment     1         0.1    92.4  57.782
+ YouthUnemploy10       1         0.1    92.4  57.793
+ BelowWage10           1         0.0    92.5  57.812
- Males                 1        12.7   105.2  59.880
- MoreMales10           1        14.8   107.3  60.815
- Males10               1        18.5   111.0  62.409
- StateSize             1        21.6   114.1  63.698
- Wage                  1        23.8   116.3  64.577
- MatureUnemployment    1        28.6   121.1  66.487
- MatureUnemploy10      1        33.0   125.5  68.156
- ExpenditureYear10     1        35.0   127.5  68.895
- Southern              1        37.0   129.5  69.621
- ExpenditureYear0      1        48.1   140.6  73.494
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- CrimeRate10           1    17471.6 17564.1 300.403


Step:  AIC=55.54
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + Wage + CrimeRate10 + ExpenditureYear10 +
    Males10 + MoreMales10 + MatureUnemploy10 + HighYouthUnemploy10


                     Df Sum of Sq     RSS     AIC
+ LabourForce10       1       4.3    83.8  55.199
<none>                              88.1  55.542
+ LabourForce         1       3.4    84.7  55.700
- HighYouthUnemploy10 1       4.4    92.5  55.825
+ Wage10              1       2.7    85.4  56.080
+ Youth              1       2.5    85.6  56.176
+ BelowWage          1       2.1    86.0  56.413
+ StateSize10        1       0.8    87.3  57.117
+ Education          1       0.5    87.6  57.249
+ YouthUnemploy10    1       0.5    87.7  57.292
+ YouthUnemployment  1       0.5    87.7  57.294
+ Education10        1       0.4    87.7  57.314
+ HighYouthUnemploy  1       0.4    87.7  57.335
+ Youth10            1       0.2    87.9  57.439
+ MoreMales          1       0.1    88.0  57.468
+ BelowWage10        1       0.1    88.0  57.477
- Males              1      15.2   103.3  61.034
- MoreMales10        1      15.4   103.6  61.128
- Males10            1      18.9   107.0  62.659
- Wage               1      22.1   110.3  64.077
- StateSize          1      24.6   112.7  65.110
- Southern           1      28.9   117.0  66.876
- MatureUnemployment 1      31.8   119.9  68.011
- MatureUnemploy10   1      37.2   125.3  70.097
- ExpenditureYear10  1      37.2   125.3  70.101
- ExpenditureYear0   1      50.9   139.0  74.974
- CrimeRate10        1    16922.4 17010.5 300.898


Step:  AIC=55.2
X...CrimeRate ~ Southern + ExpenditureYear0 + Males + StateSize +
    MatureUnemployment + Wage + CrimeRate10 + ExpenditureYear10 +
    Males10 + MoreMales10 + MatureUnemploy10 + HighYouthUnemploy10 +
```

```
         LabourForce10

                          Df Sum of Sq      RSS      AIC
<none>                                      83.8   55.199
- LabourForce10           1       4.3      88.1   55.542
+ Youth                   1       2.0      81.8   56.045
+ Wage10                  1       1.6      82.2   56.268
+ BelowWage               1       1.4      82.4   56.410
+ StateSize10             1       1.3      82.5   56.436
- HighYouthUnemploy10     1       6.0      89.8   56.450
+ Youth10                 1       0.3      83.6   57.052
+ MoreMales               1       0.3      83.6   57.058
+ Education               1       0.2      83.6   57.074
+ HighYouthUnemploy       1       0.2      83.6   57.091
+ Education10             1       0.1      83.7   57.127
+ LabourForce            1       0.1      83.7   57.132
+ BelowWage10             1       0.0      83.8   57.186
+ YouthUnemploy10         1       0.0      83.8   57.198
+ YouthUnemployment       1       0.0      83.8   57.199
- Southern                1      13.6      97.5   60.272
- MoreMales10             1      14.0      97.8   60.441
- MatureUnemployment      1      18.6     102.4   62.596
- Males10                 1      19.1     102.9   62.825
- Wage                    1      19.1     102.9   62.834
- Males                   1      19.2     103.1   62.909
- StateSize               1      28.1     111.9   66.786
- MatureUnemploy10        1      28.5     112.3   66.942
- ExpenditureYear10       1      30.9     114.7   67.934
- ExpenditureYear0        1      44.3     128.1   73.124
- CrimeRate10             1   16189.4   16273.2  300.815

Call:
lm(formula = X...CrimeRate ~ Southern + ExpenditureYear0 + Males +
    StateSize + MatureUnemployment + Wage + CrimeRate10 + ExpenditureYear10 +
    Males10 + MoreMales10 + MatureUnemploy10 + HighYouthUnemploy10 +
    LabourForce10, data = data)

Coefficients:
      (Intercept)              Southern      ExpenditureYear0
         26.29289              -2.08933               0.33513
```

Males	StateSize	MatureUnemployment
-0.05595	-0.03069	-0.40740
Wage	CrimeRate10	ExpenditureYear10
-0.01491	0.73158	-0.29560
Males10	MoreMales10	MatureUnemploy10
0.05234	-2.49654	0.47887
HighYouthUnemploy10	LabourForce10	
0.98291	0.01432	

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC <- lm(formula = X...CrimeRate ~ Southern + ExpenditureYear0 + Males +
    StateSize + MatureUnemployment + Wage + CrimeRate10 + ExpenditureYear10 +
    Males10 + MoreMales10 + MatureUnemploy10 + HighYouthUnemploy10 +
    LabourForce10, data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de `shapiro` nos resíduos

```
shapiro.test(modreg_trein_AIC$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC$residuals
W = 0.97853, p-value = 0.533
```

p-value = 0.533 ¡=¿ p-value maior que 0.05 =¿ não rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo é distribuido normalmente.

1.12 Performance de Estudantes (não normal)

- **Modelar nota final (G3) a partir das variáveis**.

1.12.1 Dados sobre o Conjunto

- Dados:

- school - Escola em que estuda (binary: 'GP' - Gabriel Pereira ou 'MS' - Mousinho da Silveira)
- sex - Sexo (binary: 'F' - mulher ou 'M' - homem)
- age - Idade (numeric: from 15 to 22)
- address - Estadia/tipo da região (binary: 'U' - urbana or 'R' - rural)
- famsize - Tamanho familhar (binary: 'LE3' - menos que 3 or 'GT3' - mais que 3)
- Pstatus - Estado de co-habitação dos pais (binary: 'T' - junto or 'A' - aparte)
- Medu - Educação da mãe (numeric: 0 - nenhuma, 1 - primária (4th ano), 2 - 5th ao 9th ano, 3 - secundária, ou 4 - superior)
- Fedu - Educação do pai (numeric: 0 - nenhuma, 1 - primária (4th ano), 2 - 5th ao 9th ano, 3 - secundária, ou 4 - superior)
- Mjob - Tabalho da mãe (nominal: 'teacher', 'health' care related, civil 'services' (e.g. administrative or police), 'at$_{home}$' or 'other')
- Fjob - Trabalho do pai (nominal: 'teacher', 'health' care related, civil 'services' (e.g. administrative or police), 'at$_{home}$' or 'other')
- reason - Razão de escolha da escola (nominal: close to 'home', school 'reputation', 'course' preference or 'other')
- guardian - Guardião legal (nominal: 'mother', 'father' or 'other')
- traveltime - Tempo de viagem, escola à casa (numeric: 1 - ¡15 min., 2 - 15 to 30 min., 3 - 30 min. to 1 hour, or 4 - ¿1 hour)
- studytime - Tempo de estudo semanal (numeric: 1 - ¡2 hours, 2 - 2 to 5 hours, 3 - 5 to 10 hours, or 4 - ¿10 hours)
- failures - Número de reprovações (numeric: n if 1¡=n¡3, else 4)
- schoolsup - Suporte educacional extra (binary: yes or no)
- famsup - Suporte educacional familiar (binary: yes or no)
- paid - Classes extras pagas (Math or Portuguese) (binary: yes or no)
- activities - Atividades extra-curriculares (binary: yes or no)
- nursery - Atendeu a clases de enfermaria (binary: yes or no)
- higher - Quer seguir educação superior (binary: yes or no)
- internet - Acesso a internet (binary: yes or no)

- romantic - Em relação romántica (binary: yes or no)
- famrel - Qualidade de relação familiar (numeric: from 1 - very bad to 5 - excellent)
- freetime - Tempo livre fora da escola (numeric: from 1 - very low to 5 - very high)
- goout - Tempo gasto saindo com amigos (numeric: from 1 - very low to 5 - very high)
- Dalc - Consumo diário de álcool (numeric: from 1 - very low to 5 - very high)
- Walc - Consumo em finais de semana de alcool (numeric: from 1 - very low to 5 - very high)
- health - Estado de saúde atual (numeric: from 1 - very bad to 5 - very good)
- absences - Número de faltas (numeric: from 0 to 93)
- G1 - Notas primeiro período (numeric: from 0 to 20) [relacionadas com português ou matemática]
- G2 - Nota segundo período (numeric: from 0 to 20) [relacionadas com português ou matemática]

- G3 - Nota final (numeric: from 0 to 20, output target) [relacionadas com português ou matemática]

1.12.2 Invocação de conjuto, por arquivo local

Dado que você copiou os conjunto(s) de dado(s) para um diretório local, pode-se chamar o conjunto de métricas e notas de Português e Matemática da seguinte maneira,

```r
data_mat=read.table("./data/csv/student-mat.csv",sep=";",header=TRUE)
data_por=read.table("./data/csv/student-por.csv",sep=";",header=TRUE)

data=merge(data_mat,data_por,by=c("school","sex","age","address","famsize","Pstatus","Medu","Fedu","Mjob","Fjob","
print(nrow(data)) # 382 dados

head(data,5)
```

```
[1] 382
  school sex age address famsize Pstatus Medu Fedu Mjob    Fjob    ...
1 GP     F   15  R       GT3     T       1    1    at_home other   ...
```

```
2 GP      F    15   R         GT3      T        1    1    other     other     ...
3 GP      F    15   R         GT3      T        2    2    at_home   other     ...
4 GP      F    15   R         GT3      T        2    4    services  health    ...
5 GP      F    15   R         GT3      T        3    3    services  services  ...
  famrel.y freetime.y goout.y Dalc.y Walc.y health.y absences.y G1.y G2.y G3.y
1 3          1          2       1      1      1        4          13   13   13
2 3          3          4       2      4      5        2          13   11   11
3 4          3          1       1      1      2        8          14   13   12
4 4          3          2       1      1      5        2          10   11   10
5 4          2          1       2      3      3        2          13   13   13
```

```
summary(data)
```

1. Transformar as variáveis categóricas em numéricas As variáveis categóricas
   são: school, sex, address, famsize, Pstatus, Mjob, Fjob, reason, nurs-
   ery, internet, guardian.x, schoolsup.x, famsup.x, paid.x, activities.x,
   higher.x, romantic.x, guardian.y, schoolsup.y, famsup.y, paid.y, activ-
   ities.y, higher.y, romantic.y.

   (a) Funções Variádicas (com número indefinido de variáveis)

   ```r
   categoricalToNumeric <- function(data,...) {
     cols <- c(...)
     data[cols] <- lapply(data[cols], function(x) as.numeric(as.factor(x)))
     summary(data)
   }

   categoricalToNumeric(data, 'school', 'sex', 'address', 'famsize', 'Pstatus', 'Mjob', 'Fjob', 'reason',
   ```

   ```r
   categoricalToNumeric2 <- function(data,...) {
     for(i in colnames(data)) {
       data[i] <- as.numeric(as.factor(data$i))
     }
     summary(data)
   }
   categoricalToNumeric2(data)
   ```

1.12.3   Regressão e Teste de Shapiro (fortemente não normal)

1. Regressão linear Agora que todas variáveis se tornaram numéricas,
   vamos aplicar a regressão linear múltipla,

```
modreg_trein_x <- lm(G3.x ~ . , data)
summary(modreg_trein_x)
```

Call:
lm(formula = G3.x ~ ., data = data)

Residuals:
    Min   1Q Median   3Q   Max
-7.7088 -0.6008 0.1906 1.0677 3.1748

Coefficients: (7 not defined because of singularities)
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)   -0.83478   2.25861 -0.370 0.711921
schoolMS   0.48091   0.40343   1.192 0.234110
sexM   0.32344   0.25226   1.282 0.200693
age   -0.26945   0.11044 -2.440 0.015232 *
addressU   -0.19584   0.28893 -0.678 0.498382
famsizeLE3   0.08357   0.23755   0.352 0.725206
PstatusT   -0.04904   0.35653 -0.138 0.890686
Medu   0.08034   0.15831   0.507 0.612151
Fedu   -0.11332   0.13594 -0.834 0.405082
Mjobhealth   -0.30835   0.54812 -0.563 0.574126
Mjobother   0.11018   0.35537   0.310 0.756724
Mjobservices   0.10697   0.39524   0.271 0.786844
Mjobteacher   -0.14028   0.50297 -0.279 0.780493
Fjobhealth   0.44124   0.73020   0.604 0.546082
Fjobother   0.05393   0.54103   0.100 0.920661
Fjobservices   -0.26772   0.55743 -0.480 0.631351
Fjobteacher   -0.07038   0.64113 -0.110 0.912657
reasonhome   -0.14785   0.26623 -0.555 0.579033
reasonother   0.41499   0.39889   1.040 0.298954
reasonreputation 0.25264   0.27975   0.903 0.367153
nurseryyes   -0.25381   0.26792 -0.947 0.344182
internetyes   -0.08858   0.31520 -0.281 0.778870
guardian.xmother -1.17129   5.32847 -0.220 0.826151
guardian.xother   0.04294   0.55972   0.077 0.938891
traveltime.x   3.13925   1.42772   2.199 0.028596 *
```

```
studytime.x         1.97125    6.20106    0.318 0.750772
failures.x         -0.10818    0.18707   -0.578 0.563469
schoolsup.xyes      3.94561    5.87479    0.672 0.502303
famsup.xyes        -4.11131   11.91675   -0.345 0.730315
paid.xyes           0.02050    0.23303    0.088 0.929964
activities.xyes    -2.75242    8.18298   -0.336 0.736817
higher.xyes         1.53770    3.80201    0.404 0.686152
romantic.xyes      -1.13930    1.42358   -0.800 0.424115
famrel.x            0.34881    0.11798    2.957 0.003338 **
freetime.x          0.06348    0.11486    0.553 0.580876
goout.x             0.08887    0.10888    0.816 0.414977
Dalc.x             -0.10430    0.16179   -0.645 0.519612
Walc.x              0.14053    0.12054    1.166 0.244532
health.x            0.09589    0.07776    1.233 0.218398
absences.x          0.06507    0.01669    3.898 0.000118 ***
G1.x                0.15545    0.06830    2.276 0.023498 *
G2.x                0.91852    0.05712   16.082  < 2e-16 ***
guardian.ymother    1.41720    5.32636    0.266 0.790352
guardian.yother          NA         NA       NA       NA
traveltime.y       -3.12203    1.42160   -2.196 0.028785 *
studytime.y        -2.13612    6.20299   -0.344 0.730790
failures.y          0.30120    0.26716    1.127 0.260395
schoolsup.yyes     -3.41026    5.87392   -0.581 0.561928
famsup.yyes         4.27988   11.91495    0.359 0.719676
paid.yyes           0.02466    0.43597    0.057 0.954920
activities.yyes     2.28851    8.16892    0.280 0.779541
higher.yyes        -1.33989    3.79014   -0.354 0.723927
romantic.yyes       0.91507    1.42357    0.643 0.520807
famrel.y                 NA         NA       NA       NA
freetime.y               NA         NA       NA       NA
goout.y                  NA         NA       NA       NA
Dalc.y                   NA         NA       NA       NA
Walc.y                   NA         NA       NA       NA
health.y                 NA         NA       NA       NA
absences.y         -0.05683    0.02599   -2.187 0.029471 *
G1.y               -0.01954    0.09293   -0.210 0.833574
G2.y                0.10256    0.12161    0.843 0.399665
G3.y                0.07778    0.08308    0.936 0.349847
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Residual standard error: 1.906 on 326 degrees of freedom
Multiple R-squared: 0.8585,Adjusted R-squared: 0.8346
F-statistic: 35.95 on 55 and 326 DF, p-value: < 2.2e-16

```
modreg_trein_y <- lm(G3.y ~ . , data)
summary(modreg_trein_y)
```

Call:
lm(formula = G3.y ~ ., data = data)

Residuals:
    Min   1Q Median   3Q   Max
-7.9301 -0.5485 -0.0070 0.5857 4.5273

Coefficients: (7 not defined because of singularities)
                Estimate Std. Error t value Pr(>|t|)
(Intercept)   -0.708822   1.503557 -0.471   0.6376
schoolMS   -0.786337   0.265637 -2.960   0.0033 **
sexM   -0.284316   0.167636 -1.696   0.0908 .
age   0.103531   0.073978   1.399   0.1626
addressU   0.141178   0.192343   0.734   0.4635
famsizeLE3   -0.213035   0.157747 -1.350   0.1778
PstatusT   -0.384705   0.236423 -1.627   0.1047
Medu   -0.116952   0.105242 -1.111   0.2673
Fedu   -0.022665   0.090592 -0.250   0.8026
Mjobhealth   0.361176   0.364562   0.991   0.3226
Mjobother   -0.241313   0.236256 -1.021   0.3078
Mjobservices   0.218045   0.262899   0.829   0.4075
Mjobteacher   0.452101   0.333977   1.354   0.1768
Fjobhealth   -0.683097   0.484957 -1.409   0.1599
Fjobother   -0.498716   0.359157 -1.389   0.1659
Fjobservices   -0.559028   0.369966 -1.511   0.1318
Fjobteacher   -0.804700   0.424530 -1.896   0.0589 .
reasonhome   0.093701   0.177262   0.529   0.5974
reasonother   -0.615429   0.263827 -2.333   0.0203 *

reasonreputation	-0.072306	0.186447	-0.388	0.6984
nurseryyes	-0.001288	0.178625	-0.007	0.9943
internetyes	0.261467	0.209384	1.249	0.2127
guardian.xmother	2.803501	3.544499	0.791	0.4296
guardian.xother	0.508093	0.371591	1.367	0.1725
traveltime.x	0.481880	0.957212	0.503	0.6150
studytime.x	-1.634897	4.128243	-0.396	0.6923
failures.x	-0.199805	0.124118	-1.610	0.1084
schoolsup.xyes	-2.448388	3.911720	-0.626	0.5318
famsup.xyes	4.196858	7.932075	0.529	0.5971
paid.xyes	-0.170457	0.154863	-1.101	0.2718
activities.xyes	1.246566	5.448638	0.229	0.8192
higher.xyes	1.731763	2.530151	0.684	0.4942
romantic.xyes	-0.562372	0.948220	-0.593	0.5535
famrel.x	0.078403	0.079477	0.986	0.3246
freetime.x	-0.030149	0.076487	-0.394	0.6937
goout.x	-0.053470	0.072507	-0.737	0.4614
Dalc.x	-0.048269	0.107756	-0.448	0.6545
Walc.x	0.034453	0.080401	0.429	0.6686
health.x	-0.061668	0.051781	-1.191	0.2345
absences.x	-0.022687	0.011300	-2.008	0.0455 *
G1.x	0.055496	0.045730	1.214	0.2258
G2.x	-0.037681	0.050881	-0.741	0.4595
G3.x	0.034477	0.036825	0.936	0.3498
guardian.ymother	-2.688266	3.543488	-0.759	0.4486
guardian.yother	NA	NA	NA	NA
traveltime.y	-0.300566	0.953312	-0.315	0.7527
studytime.y	1.655202	4.129611	0.401	0.6888
failures.y	-0.413080	0.176746	-2.337	0.0200 *
schoolsup.yyes	2.363260	3.910619	0.604	0.5461
famsup.yyes	-4.058048	7.931220	-0.512	0.6092
paid.yyes	-0.066205	0.290245	-0.228	0.8197
activities.yyes	-1.085456	5.439090	-0.200	0.8419
higher.yyes	-1.362799	2.522784	-0.540	0.5894
romantic.yyes	0.696680	0.947613	0.735	0.4627
famrel.y	NA	NA	NA	NA
freetime.y	NA	NA	NA	NA
goout.y	NA	NA	NA	NA
Dalc.y	NA	NA	NA	NA
Walc.y	NA	NA	NA	NA

```
health.y                    NA       NA      NA      NA
absences.y        0.036818   0.017310  2.127  0.0342 *
G1.y              0.135017   0.061425  2.198  0.0286 *
G2.y              0.808075   0.067577 11.958  <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.269 on 326 degrees of freedom
Multiple R-squared:  0.8411,Adjusted R-squared:  0.8143
F-statistic: 31.38 on 55 and 326 DF,  p-value: < 2.2e-16
```

2. StepAIC

```
library(MASS)
```

```
stepAIC(modreg_trein_x, direction="both", keep=NULL)
```

```
Start:  AIC=544.38
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + famrel.y + freetime.y + goout.y + Dalc.y + Walc.y +
    health.y + absences.y + G1.y + G2.y + G3.y


Step:  AIC=544.38
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
```

```
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + famrel.y + freetime.y + goout.y + Dalc.y + Walc.y +
    absences.y + G1.y + G2.y + G3.y


Step:  AIC=544.38
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + famrel.y + freetime.y + goout.y + Dalc.y + absences.y +
    G1.y + G2.y + G3.y


Step:  AIC=544.38
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + famrel.y + freetime.y + goout.y + absences.y +
    G1.y + G2.y + G3.y


Step:  AIC=544.38
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + famrel.y + freetime.y + absences.y + G1.y +
    G2.y + G3.y
```

```
Step:  AIC=544.38
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + famrel.y + absences.y + G1.y + G2.y + G3.y


Step:  AIC=544.38
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + absences.y + G1.y + G2.y + G3.y
```

	Df	Sum of Sq	RSS	AIC
- Mjob	4	4.84	1189.6	537.94
- Fjob	4	9.52	1194.3	539.44
- reason	3	10.84	1195.6	541.86
- paid.y	1	0.01	1184.8	542.39
- paid.x	1	0.03	1184.8	542.39
- Pstatus	1	0.07	1184.8	542.41
- G1.y	1	0.16	1185.0	542.44
- guardian.x	1	0.18	1185.0	542.44
- guardian.y	1	0.26	1185.0	542.47
- activities.y	1	0.29	1185.1	542.48
- internet	1	0.29	1185.1	542.48
- studytime.x	1	0.37	1185.2	542.50
- activities.x	1	0.41	1185.2	542.52
- studytime.y	1	0.43	1185.2	542.52
- famsup.x	1	0.43	1185.2	542.52
- famsize	1	0.45	1185.2	542.53
- higher.y	1	0.45	1185.2	542.53

```
- famsup.y      1        0.47 1185.2 542.54
- higher.x      1        0.59 1185.4 542.58
- Medu          1        0.94 1185.7 542.69
- freetime.x    1        1.11 1185.9 542.74
- failures.x    1        1.22 1186.0 542.78
- schoolsup.y   1        1.23 1186.0 542.78
- romantic.y    1        1.50 1186.3 542.87
- Dalc.x        1        1.51 1186.3 542.87
- schoolsup.x   1        1.64 1186.4 542.91
- address       1        1.67 1186.5 542.92
- romantic.x    1        2.33 1187.1 543.13
- goout.x       1        2.42 1187.2 543.16
- Fedu          1        2.53 1187.3 543.20
- G2.y          1        2.58 1187.4 543.22
- G3.y          1        3.19 1188.0 543.41
- nursery       1        3.26 1188.0 543.43
- failures.y    1        4.62 1189.4 543.87
- Walc.x        1        4.94 1189.7 543.97
- school        1        5.16 1190.0 544.05
- health.x      1        5.53 1190.3 544.16
- sex           1        5.97 1190.8 544.31
<none>                       1184.8 544.38
- absences.y    1       17.38 1202.2 547.95
- traveltime.y  1       17.53 1202.3 547.99
- traveltime.x  1       17.57 1202.4 548.01
- G1.x          1       18.83 1203.6 548.41
- age           1       21.63 1206.4 549.30
- famrel.x      1       31.77 1216.5 552.49
- absences.x    1       55.23 1240.0 559.79
- G2.x          1      939.89 2124.7 765.49

Step:  AIC=537.94
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + absences.y + G1.y + G2.y + G3.y
```

```
                Df Sum of Sq    RSS     AIC
- Fjob           4      9.79 1199.4  533.07
- reason         3     11.22 1200.8  535.53
- paid.x         1      0.00 1189.6  535.94
- paid.y         1      0.02 1189.7  535.95
- G1.y           1      0.10 1189.7  535.97
- Medu           1      0.15 1189.8  535.99
- guardian.x     1      0.20 1189.8  536.01
- famsize        1      0.25 1189.9  536.02
- Pstatus        1      0.26 1189.9  536.03
- guardian.y     1      0.28 1189.9  536.03
- activities.y   1      0.29 1189.9  536.04
- studytime.x    1      0.35 1190.0  536.06
- internet       1      0.37 1190.0  536.06
- studytime.y    1      0.41 1190.0  536.07
- activities.x   1      0.43 1190.0  536.08
- higher.y       1      0.43 1190.1  536.08
- famsup.x       1      0.45 1190.1  536.09
- famsup.y       1      0.48 1190.1  536.10
- higher.x       1      0.57 1190.2  536.13
- Dalc.x         1      0.93 1190.6  536.24
- freetime.x     1      0.99 1190.6  536.26
- failures.x     1      1.02 1190.7  536.27
- schoolsup.y    1      1.14 1190.8  536.31
- address        1      1.43 1191.1  536.40
- schoolsup.x    1      1.58 1191.2  536.45
- romantic.y     1      1.60 1191.2  536.45
- Fedu           1      2.19 1191.8  536.64
- romantic.x     1      2.40 1192.0  536.71
- goout.x        1      2.49 1192.1  536.74
- G2.y           1      2.55 1192.2  536.76
- G3.y           1      2.58 1192.2  536.77
- nursery        1      3.75 1193.4  537.15
- Walc.x         1      3.97 1193.6  537.22
- failures.y     1      4.09 1193.7  537.25
- school         1      5.30 1194.9  537.64
- health.x       1      5.46 1195.1  537.69
- sex            1      6.04 1195.7  537.88
<none>                       1189.6  537.94
```

```
- absences.y     1      16.24 1205.9 541.12
- traveltime.y   1      17.63 1207.3 541.56
- traveltime.x   1      17.76 1207.4 541.60
- G1.x           1      18.74 1208.4 541.91
- age            1      20.69 1210.3 542.53
+ Mjob           4       4.84 1184.8 544.38
- famrel.x       1      35.53 1225.2 547.18
- absences.x     1      56.61 1246.2 553.70
- G2.x           1     963.32 2152.9 762.54

Step:  AIC=533.07
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + reason + nursery + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
    activities.x + higher.x + romantic.x + famrel.x + freetime.x +
    goout.x + Dalc.x + Walc.x + health.x + absences.x + G1.x +
    G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + absences.y + G1.y + G2.y + G3.y

               Df Sum of Sq    RSS    AIC
- reason         3      12.13 1211.5 530.92
- paid.y         1       0.02 1199.4 531.08
- paid.x         1       0.08 1199.5 531.10
- G1.y           1       0.09 1199.5 531.10
- Medu           1       0.21 1199.6 531.14
- higher.y       1       0.25 1199.7 531.15
- higher.x       1       0.40 1199.8 531.20
- guardian.x     1       0.40 1199.8 531.20
- famsize        1       0.47 1199.9 531.22
- guardian.y     1       0.53 1200.0 531.24
- Pstatus        1       0.53 1200.0 531.24
- activities.y   1       0.62 1200.0 531.27
- studytime.x    1       0.68 1200.1 531.29
- studytime.y    1       0.76 1200.2 531.31
- famsup.x       1       0.77 1200.2 531.32
- activities.x   1       0.81 1200.2 531.33
- famsup.y       1       0.82 1200.2 531.33
- internet       1       0.94 1200.4 531.37
- address        1       1.51 1200.9 531.55
```

```
- freetime.x     1        1.63 1201.0 531.59
- Dalc.x         1        1.65 1201.1 531.60
- romantic.y     1        1.73 1201.2 531.62
- schoolsup.y    1        1.82 1201.2 531.65
- failures.x     1        1.83 1201.2 531.65
- schoolsup.x    1        2.38 1201.8 531.83
- G3.y           1        2.47 1201.9 531.86
- romantic.x     1        2.57 1202.0 531.89
- G2.y           1        2.69 1202.1 531.93
- Fedu           1        2.92 1202.3 532.00
- goout.x        1        3.05 1202.5 532.04
- Walc.x         1        3.72 1203.1 532.26
- school         1        4.05 1203.5 532.36
- nursery        1        4.21 1203.6 532.41
- failures.y     1        5.17 1204.6 532.72
<none>                         1199.4 533.07
- sex            1        6.80 1206.2 533.23
- health.x       1        6.84 1206.3 533.25
- absences.y     1       14.66 1214.1 535.71
- traveltime.y   1       17.10 1216.5 536.48
- traveltime.x   1       17.32 1216.7 536.55
- G1.x           1       18.87 1218.3 537.04
- age            1       21.55 1221.0 537.88
+ Fjob           4        9.79 1189.6 537.94
+ Mjob           4        5.11 1194.3 539.44
- famrel.x       1       34.02 1233.4 541.76
- absences.x     1       54.96 1254.4 548.19
- G2.x           1      981.49 2180.9 759.47

Step:  AIC=530.92
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + nursery + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + freetime.x + goout.x +
    Dalc.x + Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + failures.y + schoolsup.y + famsup.y +
    paid.y + activities.y + higher.y + romantic.y + absences.y +
    G1.y + G2.y + G3.y

             Df Sum of Sq    RSS     AIC
```

```
- G1.y          1      0.04 1211.6 528.93
- paid.y        1      0.11 1211.7 528.95
- paid.x        1      0.14 1211.7 528.96
- higher.y      1      0.21 1211.8 528.98
- higher.x      1      0.30 1211.8 529.01
- famsize       1      0.41 1212.0 529.05
- guardian.x    1      0.44 1212.0 529.06
- guardian.y    1      0.58 1212.1 529.10
- Medu          1      0.68 1212.2 529.13
- Pstatus       1      0.70 1212.2 529.14
- activities.y  1      0.70 1212.2 529.14
- studytime.x   1      0.78 1212.3 529.16
- famsup.x      1      0.85 1212.4 529.19
- studytime.y   1      0.86 1212.4 529.19
- activities.x  1      0.89 1212.4 529.20
- famsup.y      1      0.90 1212.5 529.20
- internet      1      1.23 1212.8 529.31
- G3.y          1      1.39 1212.9 529.36
- Dalc.x        1      1.52 1213.1 529.40
- romantic.y    1      1.79 1213.3 529.48
- schoolsup.y   1      1.81 1213.4 529.49
- freetime.x    1      2.04 1213.6 529.56
- failures.x    1      2.27 1213.8 529.63
- schoolsup.x   1      2.37 1213.9 529.66
- romantic.x    1      2.58 1214.1 529.73
- goout.x       1      2.67 1214.2 529.76
- address       1      3.02 1214.6 529.87
- G2.y          1      3.10 1214.7 529.90
- Fedu          1      3.52 1215.1 530.03
- school        1      3.87 1215.4 530.14
- nursery       1      4.18 1215.7 530.23
- Walc.x        1      4.47 1216.0 530.32
- sex           1      4.77 1216.3 530.42
- failures.y    1      5.08 1216.6 530.52
- health.x      1      5.42 1217.0 530.62
<none>                      1211.5 530.92
+ reason        3     12.13 1199.4 533.07
- absences.y    1     15.25 1226.8 533.70
- traveltime.y  1     17.31 1228.9 534.34
- traveltime.x  1     17.45 1229.0 534.38
```

```
- G1.x            1      18.66 1230.2 534.76
+ Fjob            4      10.70 1200.8 535.53
- age             1      22.37 1233.9 535.91
+ Mjob            4       5.06 1206.5 537.32
- famrel.x        1      35.75 1247.3 540.03
- absences.x      1      53.19 1264.7 545.33
- G2.x            1    1005.96 2217.5 759.83

Step:  AIC=528.93
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + nursery + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + freetime.x + goout.x +
    Dalc.x + Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + failures.y + schoolsup.y + famsup.y +
    paid.y + activities.y + higher.y + romantic.y + absences.y +
    G2.y + G3.y

                 Df Sum of Sq    RSS     AIC
- paid.y          1       0.10 1211.7 526.96
- paid.x          1       0.13 1211.7 526.97
- higher.y        1       0.20 1211.8 526.99
- higher.x        1       0.30 1211.9 527.02
- famsize         1       0.38 1212.0 527.05
- guardian.x      1       0.45 1212.0 527.07
- guardian.y      1       0.59 1212.2 527.12
- Medu            1       0.67 1212.3 527.14
- activities.y    1       0.72 1212.3 527.16
- Pstatus         1       0.74 1212.3 527.16
- studytime.x     1       0.81 1212.4 527.18
- famsup.x        1       0.87 1212.5 527.20
- studytime.y     1       0.88 1212.5 527.21
- activities.x    1       0.91 1212.5 527.22
- famsup.y        1       0.93 1212.5 527.22
- internet        1       1.24 1212.8 527.32
- G3.y            1       1.36 1213.0 527.36
- Dalc.x          1       1.51 1213.1 527.41
- romantic.y      1       1.79 1213.4 527.49
- schoolsup.y     1       1.84 1213.4 527.51
- freetime.x      1       2.05 1213.6 527.57
```

```
- failures.x    1        2.36 1214.0 527.67
- schoolsup.x   1        2.41 1214.0 527.69
- romantic.x    1        2.59 1214.2 527.75
- goout.x       1        2.63 1214.2 527.76
- address       1        2.99 1214.6 527.87
- Fedu          1        3.50 1215.1 528.03
- school        1        3.94 1215.5 528.17
- nursery       1        4.15 1215.7 528.24
- G2.y          1        4.16 1215.7 528.24
- Walc.x        1        4.50 1216.1 528.34
- sex           1        4.83 1216.4 528.45
- failures.y    1        5.11 1216.7 528.54
- health.x      1        5.40 1217.0 528.63
<none>                        1211.6 528.93
+ G1.y          1        0.04 1211.5 530.92
+ reason        3       12.08 1199.5 531.10
- absences.y    1       15.22 1226.8 531.70
- traveltime.y  1       17.29 1228.9 532.34
- traveltime.x  1       17.43 1229.0 532.39
- G1.x          1       18.79 1230.4 532.81
+ Fjob          4       10.67 1200.9 533.55
- age           1       22.66 1234.2 534.01
+ Mjob          4        5.03 1206.6 535.34
- famrel.x      1       36.13 1247.7 538.15
- absences.x    1       53.38 1265.0 543.40
- G2.x          1     1011.84 2223.4 758.85

Step:  AIC=526.96
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + nursery + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + freetime.x + goout.x +
    Dalc.x + Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + failures.y + schoolsup.y + famsup.y +
    activities.y + higher.y + romantic.y + absences.y + G2.y +
    G3.y

              Df Sum of Sq    RSS    AIC
- paid.x        1        0.12 1211.8 525.00
- higher.y      1        0.17 1211.9 525.02
```

```
- higher.x      1       0.27 1212.0 525.05
- famsize       1       0.39 1212.1 525.08
- guardian.x    1       0.53 1212.2 525.13
- Medu          1       0.66 1212.3 525.17
- guardian.y    1       0.68 1212.4 525.18
- Pstatus       1       0.73 1212.4 525.19
- activities.y  1       0.82 1212.5 525.22
- studytime.x   1       0.90 1212.6 525.24
- famsup.x      1       0.98 1212.7 525.27
- studytime.y   1       0.98 1212.7 525.27
- activities.x  1       1.03 1212.7 525.29
- famsup.y      1       1.03 1212.7 525.29
- internet      1       1.25 1212.9 525.36
- G3.y          1       1.37 1213.1 525.39
- Dalc.x        1       1.59 1213.3 525.46
- romantic.y    1       1.82 1213.5 525.54
- schoolsup.y   1       1.99 1213.7 525.59
- freetime.x    1       2.11 1213.8 525.63
- failures.x    1       2.36 1214.0 525.71
- schoolsup.x   1       2.58 1214.3 525.77
- goout.x       1       2.62 1214.3 525.79
- romantic.x    1       2.63 1214.3 525.79
- address       1       2.92 1214.6 525.88
- Fedu          1       3.59 1215.3 526.09
- school        1       3.85 1215.5 526.17
- nursery       1       4.17 1215.9 526.27
- G2.y          1       4.19 1215.9 526.28
- Walc.x        1       4.58 1216.3 526.40
- sex           1       4.73 1216.4 526.45
- failures.y    1       5.00 1216.7 526.54
- health.x      1       5.35 1217.0 526.64
<none>                       1211.7 526.96
+ paid.y        1       0.10 1211.6 528.93
+ G1.y          1       0.03 1211.7 528.95
+ reason        3      12.17 1199.5 529.11
- absences.y    1      15.13 1226.8 529.70
- traveltime.y  1      17.23 1228.9 530.36
- traveltime.x  1      17.39 1229.1 530.41
- G1.x          1      19.00 1230.7 530.91
+ Fjob          4      10.71 1201.0 531.57
```

```
- age            1      22.58 1234.3 532.02
+ Mjob           4       4.96 1206.7 533.39
- famrel.x       1      36.05 1247.7 536.16
- absences.x     1      53.27 1265.0 541.40
- G2.x           1    1012.62 2224.3 757.00

Step:  AIC=525
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + nursery + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + activities.x + higher.x +
    romantic.x + famrel.x + freetime.x + goout.x + Dalc.x + Walc.x +
    health.x + absences.x + G1.x + G2.x + guardian.y + traveltime.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + activities.y +
    higher.y + romantic.y + absences.y + G2.y + G3.y

                  Df Sum of Sq    RSS     AIC
- higher.y        1       0.17 1212.0 523.05
- higher.x        1       0.27 1212.1 523.09
- famsize         1       0.39 1212.2 523.12
- guardian.x      1       0.53 1212.3 523.17
- guardian.y      1       0.68 1212.5 523.21
- Medu            1       0.68 1212.5 523.21
- Pstatus         1       0.68 1212.5 523.22
- activities.y    1       0.83 1212.6 523.26
- studytime.x     1       0.91 1212.7 523.29
- famsup.x        1       0.99 1212.8 523.31
- studytime.y     1       1.00 1212.8 523.31
- activities.x    1       1.04 1212.8 523.33
- famsup.y        1       1.04 1212.9 523.33
- internet        1       1.18 1213.0 523.37
- G3.y            1       1.33 1213.1 523.42
- Dalc.x          1       1.55 1213.4 523.49
- romantic.y      1       1.81 1213.6 523.57
- schoolsup.y     1       2.00 1213.8 523.63
- freetime.x      1       2.05 1213.9 523.65
- failures.x      1       2.46 1214.3 523.78
- goout.x         1       2.59 1214.4 523.82
- schoolsup.x     1       2.59 1214.4 523.82
- romantic.x      1       2.61 1214.4 523.82
- address         1       2.90 1214.7 523.91
```

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- Fedu          1       3.64 1215.5 524.15
- school        1       3.88 1215.7 524.22
- nursery       1       4.07 1215.9 524.28
- G2.y          1       4.22 1216.0 524.33
- sex           1       4.64 1216.5 524.46
- Walc.x        1       4.83 1216.6 524.52
- failures.y    1       4.91 1216.7 524.55
- health.x      1       5.26 1217.1 524.66
<none>                       1211.8 525.00
+ paid.x        1       0.12 1211.7 526.96
+ paid.y        1       0.09 1211.7 526.97
+ G1.y          1       0.03 1211.8 526.99
+ reason        3      12.21 1199.6 527.13
- absences.y    1      15.80 1227.6 527.95
- traveltime.y  1      17.23 1229.0 528.39
- traveltime.x  1      17.38 1229.2 528.44
- G1.x          1      18.88 1230.7 528.91
+ Fjob          4      10.82 1201.0 529.57
- age           1      22.50 1234.3 530.03
+ Mjob          4       4.81 1207.0 531.48
- famrel.x      1      36.17 1248.0 534.24
- absences.x    1      53.45 1265.3 539.49
- G2.x          1    1023.49 2235.3 756.88

Step:  AIC=523.05
G3.x ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + nursery + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + activities.x + higher.x +
    romantic.x + famrel.x + freetime.x + goout.x + Dalc.x + Walc.x +
    health.x + absences.x + G1.x + G2.x + guardian.y + traveltime.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + activities.y +
    romantic.y + absences.y + G2.y + G3.y

             Df Sum of Sq    RSS    AIC
- famsize     1       0.38 1212.4 521.17
- higher.x    1       0.53 1212.5 521.22
- Medu        1       0.67 1212.7 521.26
- Pstatus     1       0.67 1212.7 521.27
- internet    1       1.11 1213.1 521.41
- G3.y        1       1.36 1213.3 521.48
```

```
- Dalc.x        1      1.57 1213.6 521.55
- freetime.x    1      2.13 1214.1 521.72
- failures.x    1      2.49 1214.5 521.84
- romantic.y    1      2.62 1214.6 521.88
- goout.x       1      2.77 1214.8 521.93
- address       1      2.99 1215.0 522.00
- Fedu          1      3.61 1215.6 522.19
- romantic.x    1      3.66 1215.7 522.21
- school        1      3.77 1215.8 522.24
- nursery       1      4.05 1216.0 522.33
- G2.y          1      4.25 1216.2 522.39
- sex           1      4.62 1216.6 522.51
- Walc.x        1      4.86 1216.8 522.58
- failures.y    1      4.96 1217.0 522.62
- health.x      1      5.30 1217.3 522.72
- activities.y  1      5.95 1217.9 522.93
<none>                      1212.0 523.05
- schoolsup.y   1      6.54 1218.5 523.11
- activities.x  1      7.05 1219.0 523.27
- guardian.x    1      7.08 1219.1 523.28
- studytime.x   1      7.11 1219.1 523.29
- studytime.y   1      7.58 1219.6 523.44
- schoolsup.x   1      8.16 1220.1 523.62
- guardian.y    1      8.32 1220.3 523.67
- famsup.x      1     10.33 1222.3 524.30
- famsup.y      1     10.75 1222.7 524.43
+ higher.y      1      0.17 1211.8 525.00
+ famrel.y      1      0.17 1211.8 525.00
+ freetime.y    1      0.17 1211.8 525.00
+ goout.y       1      0.17 1211.8 525.00
+ Dalc.y        1      0.17 1211.8 525.00
+ health.y      1      0.17 1211.8 525.00
+ paid.x        1      0.12 1211.9 525.02
+ paid.y        1      0.07 1211.9 525.03
+ G1.y          1      0.03 1212.0 525.05
+ reason        3     12.12 1199.9 525.21
- absences.y    1     16.42 1228.4 526.19
- G1.x          1     18.82 1230.8 526.94
- traveltime.y  1     18.92 1230.9 526.97
- traveltime.x  1     19.08 1231.1 527.02
```

```
+ Fjob          4      10.67 1201.3 527.68
- age           1      22.42 1234.4 528.06
+ Mjob          4       4.72 1207.3 529.56
- famrel.x      1      37.32 1249.3 532.64
- absences.x    1      54.07 1266.1 537.73
- G2.x          1    1023.51 2235.5 754.92

Step:  AIC=521.17
G3.x ~ school + sex + age + address + Pstatus + Medu + Fedu +
    nursery + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + activities.x + higher.x +
    romantic.x + famrel.x + freetime.x + goout.x + Dalc.x + Walc.x +
    health.x + absences.x + G1.x + G2.x + guardian.y + traveltime.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + activities.y +
    romantic.y + absences.y + G2.y + G3.y

                Df Sum of Sq    RSS    AIC
- higher.x      1       0.53 1212.9 519.34
- Medu          1       0.62 1213.0 519.37
- Pstatus       1       0.84 1213.2 519.44
- internet      1       1.06 1213.4 519.51
- G3.y          1       1.33 1213.7 519.59
- Dalc.x        1       1.51 1213.9 519.65
- freetime.x    1       2.16 1214.5 519.86
- failures.x    1       2.51 1214.9 519.97
- romantic.y    1       2.58 1214.9 519.99
- goout.x       1       2.73 1215.1 520.03
- address       1       2.86 1215.2 520.07
- romantic.x    1       3.60 1216.0 520.31
- Fedu          1       3.72 1216.1 520.34
- nursery       1       3.80 1216.2 520.37
- school        1       3.82 1216.2 520.38
- G2.y          1       4.37 1216.7 520.55
- sex           1       4.78 1217.1 520.68
- failures.y    1       4.84 1217.2 520.70
- Walc.x        1       4.99 1217.3 520.74
- health.x      1       5.21 1217.6 520.81
- activities.y  1       5.97 1218.3 521.05
<none>                       1212.4 521.17
- schoolsup.y   1       6.51 1218.9 521.22
```

```
- activities.x  1       7.08 1219.4 521.40
- guardian.x    1       7.11 1219.5 521.41
- studytime.x   1       7.16 1219.5 521.42
- studytime.y   1       7.64 1220.0 521.57
- schoolsup.x   1       8.13 1220.5 521.73
- guardian.y    1       8.37 1220.7 521.80
- famsup.x      1      10.37 1222.7 522.43
- famsup.y      1      10.77 1223.1 522.55
+ famsize       1       0.38 1212.0 523.05
+ higher.y      1       0.16 1212.2 523.12
+ famrel.y      1       0.16 1212.2 523.12
+ freetime.y    1       0.16 1212.2 523.12
+ goout.y       1       0.16 1212.2 523.12
+ Dalc.y        1       0.16 1212.2 523.12
+ health.y      1       0.16 1212.2 523.12
+ paid.x        1       0.12 1212.2 523.14
+ paid.y        1       0.07 1212.3 523.15
+ G1.y          1       0.01 1212.4 523.17
+ reason        3      12.08 1200.3 523.35
- absences.y    1      16.55 1228.9 524.36
- G1.x          1      18.84 1231.2 525.06
- traveltime.y  1      19.02 1231.4 525.12
- traveltime.x  1      19.24 1231.6 525.19
+ Fjob          4      10.88 1201.5 525.73
- age           1      22.36 1234.7 526.16
+ Mjob          4       4.44 1207.9 527.77
- famrel.x      1      37.26 1249.6 530.74
- absences.x    1      54.45 1266.8 535.96
- G2.x          1    1025.95 2238.3 753.40

Step:  AIC=519.34
G3.x ~ school + sex + age + address + Pstatus + Medu + Fedu +
    nursery + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + activities.x + romantic.x +
    famrel.x + freetime.x + goout.x + Dalc.x + Walc.x + health.x +
    absences.x + G1.x + G2.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + activities.y + romantic.y +
    absences.y + G2.y + G3.y

              Df Sum of Sq    RSS     AIC
```

```
- Medu          1      0.64 1213.5 517.54
- Pstatus       1      0.86 1213.8 517.61
- internet      1      1.17 1214.1 517.71
- G3.y          1      1.44 1214.3 517.80
- Dalc.x        1      1.45 1214.3 517.80
- freetime.x    1      2.20 1215.1 518.03
- romantic.y    1      2.68 1215.6 518.18
- goout.x       1      2.74 1215.6 518.20
- address       1      2.84 1215.7 518.24
- failures.x    1      3.05 1216.0 518.30
- Fedu          1      3.65 1216.5 518.49
- romantic.x    1      3.79 1216.7 518.53
- nursery       1      3.81 1216.7 518.54
- school        1      4.21 1217.1 518.66
- G2.y          1      4.47 1217.4 518.75
- sex           1      4.48 1217.4 518.75
- failures.y    1      4.66 1217.5 518.81
- Walc.x        1      5.11 1218.0 518.95
- health.x      1      5.21 1218.1 518.98
<none>                 1212.9 519.34
- activities.y  1      6.56 1219.5 519.40
- schoolsup.y   1      6.97 1219.9 519.53
- activities.x  1      7.70 1220.6 519.76
- studytime.x   1      7.88 1220.8 519.81
- guardian.x    1      7.96 1220.9 519.84
- studytime.y   1      8.37 1221.3 519.97
- schoolsup.x   1      8.65 1221.5 520.06
- guardian.y    1      9.29 1222.2 520.26
- famsup.x      1     11.48 1224.4 520.94
- famsup.y      1     11.93 1224.8 521.08
+ higher.x      1      0.53 1212.4 521.17
+ higher.y      1      0.44 1212.5 521.20
+ famsize       1      0.38 1212.5 521.22
+ famrel.y      1      0.19 1212.7 521.28
+ freetime.y    1      0.19 1212.7 521.28
+ goout.y       1      0.19 1212.7 521.28
+ Dalc.y        1      0.19 1212.7 521.28
+ health.y      1      0.19 1212.7 521.28
+ paid.x        1      0.18 1212.7 521.29
+ paid.y        1      0.05 1212.8 521.32
```

```
+ G1.y           1       0.01 1212.9 521.34
+ reason         3      11.70 1201.2 521.64
- absences.y     1      17.15 1230.0 522.71
- traveltime.y   1      18.64 1231.5 523.17
- traveltime.x   1      18.86 1231.8 523.24
- G1.x           1      19.07 1232.0 523.30
+ Fjob           4      11.11 1201.8 523.83
- age            1      24.75 1237.6 525.06
+ Mjob           4       4.58 1208.3 525.90
- famrel.x       1      37.53 1250.4 528.98
- absences.x     1      55.42 1268.3 534.41
- G2.x           1    1025.62 2238.5 751.43

Step:  AIC=517.54
G3.x ~ school + sex + age + address + Pstatus + Fedu + nursery +
    internet + guardian.x + traveltime.x + studytime.x + failures.x +
    schoolsup.x + famsup.x + activities.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + activities.y + romantic.y + absences.y +
    G2.y + G3.y

                Df Sum of Sq     RSS     AIC
- Pstatus        1       0.96 1214.5 515.85
- internet       1       1.03 1214.6 515.87
- Dalc.x         1       1.28 1214.8 515.95
- G3.y           1       1.41 1215.0 515.99
- freetime.x     1       2.24 1215.8 516.25
- romantic.y     1       2.63 1216.2 516.37
- address        1       2.69 1216.2 516.39
- goout.x        1       2.90 1216.4 516.46
- failures.x     1       3.13 1216.7 516.53
- Fedu           1       3.15 1216.7 516.53
- nursery        1       3.55 1217.1 516.66
- romantic.x     1       3.73 1217.3 516.72
- school         1       4.15 1217.7 516.85
- failures.y     1       4.55 1218.1 516.98
- G2.y           1       4.67 1218.2 517.01
- Walc.x         1       4.83 1218.4 517.06
- sex            1       4.99 1218.5 517.11
```

```
- health.x        1       5.07 1218.6 517.14
<none>                         1213.5 517.54
- activities.y  1       6.41 1220.0 517.56
- schoolsup.y   1       6.79 1220.3 517.68
- activities.x  1       7.53 1221.1 517.91
- studytime.x   1       7.76 1221.3 517.98
- guardian.x    1       7.85 1221.4 518.01
- studytime.y   1       8.24 1221.8 518.13
- schoolsup.x   1       8.42 1222.0 518.19
- guardian.y    1       9.26 1222.8 518.45
- famsup.x      1      11.33 1224.9 519.09
- famsup.y      1      11.78 1225.3 519.24
+ Medu          1       0.64 1212.9 519.34
+ higher.x      1       0.55 1213.0 519.37
+ higher.y      1       0.46 1213.1 519.40
+ famsize       1       0.33 1213.2 519.44
+ paid.x        1       0.20 1213.3 519.48
+ famrel.y      1       0.18 1213.3 519.49
+ freetime.y    1       0.18 1213.3 519.49
+ goout.y       1       0.18 1213.3 519.49
+ Dalc.y        1       0.18 1213.3 519.49
+ health.y      1       0.18 1213.3 519.49
+ paid.y        1       0.04 1213.5 519.53
+ G1.y          1       0.01 1213.5 519.54
+ reason        3      12.14 1201.4 519.70
- absences.y    1      17.37 1230.9 520.97
- traveltime.y  1      18.76 1232.3 521.40
- G1.x          1      18.91 1232.5 521.45
- traveltime.x  1      18.94 1232.5 521.46
+ Fjob          4      11.27 1202.3 521.98
- age           1      25.03 1238.6 523.34
+ Mjob          4       3.65 1209.9 524.39
- famrel.x      1      37.31 1250.8 527.11
- absences.x    1      57.42 1271.0 533.20
- G2.x          1    1028.02 2241.6 749.95

Step:  AIC=515.85
G3.x ~ school + sex + age + address + Fedu + nursery + internet +
    guardian.x + traveltime.x + studytime.x + failures.x + schoolsup.x +
    famsup.x + activities.x + romantic.x + famrel.x + freetime.x +
```

```
        goout.x + Dalc.x + Walc.x + health.x + absences.x + G1.x +
        G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
        schoolsup.y + famsup.y + activities.y + romantic.y + absences.y +
        G2.y + G3.y

                    Df Sum of Sq    RSS    AIC
- Dalc.x          1       1.14 1215.6 514.20
- internet        1       1.20 1215.7 514.22
- G3.y            1       1.58 1216.1 514.34
- freetime.x      1       2.14 1216.6 514.52
- address         1       2.60 1217.1 514.66
- romantic.y      1       2.62 1217.1 514.67
- Fedu            1       2.87 1217.4 514.75
- failures.x      1       2.93 1217.4 514.77
- goout.x         1       2.95 1217.5 514.77
- nursery         1       3.39 1217.9 514.91
- romantic.x      1       3.68 1218.2 515.00
- school          1       4.04 1218.5 515.12
- failures.y      1       4.40 1218.9 515.23
- Walc.x          1       4.53 1219.0 515.27
- G2.y            1       4.63 1219.1 515.30
- health.x        1       4.96 1219.5 515.40
- sex             1       5.19 1219.7 515.48
<none>                         1214.5 515.85
- activities.y    1       6.46 1221.0 515.87
- schoolsup.y     1       6.84 1221.3 515.99
- activities.x    1       7.62 1222.1 516.23
- studytime.x     1       7.86 1222.4 516.31
- guardian.x      1       7.94 1222.4 516.34
- studytime.y     1       8.34 1222.8 516.46
- schoolsup.x     1       8.50 1223.0 516.51
- guardian.y      1       9.42 1223.9 516.80
- famsup.x        1      11.45 1226.0 517.43
+ Pstatus         1       0.96 1213.5 517.54
- famsup.y        1      11.89 1226.4 517.57
+ Medu            1       0.75 1213.8 517.61
+ higher.x        1       0.58 1213.9 517.67
+ famsize         1       0.49 1214.0 517.69
+ higher.y        1       0.48 1214.0 517.69
+ famrel.y        1       0.17 1214.3 517.79
```

```
+ freetime.y     1        0.17 1214.3 517.79
+ goout.y        1        0.17 1214.3 517.79
+ Dalc.y         1        0.17 1214.3 517.79
+ health.y       1        0.17 1214.3 517.79
+ paid.x         1        0.13 1214.4 517.81
+ paid.y         1        0.04 1214.5 517.84
+ G1.y           1        0.03 1214.5 517.84
+ reason         3       12.32 1202.2 517.95
- absences.y     1       17.69 1232.2 519.37
- G1.x           1       18.49 1233.0 519.62
- traveltime.y   1       18.72 1233.2 519.69
- traveltime.x   1       18.91 1233.4 519.75
+ Fjob           4       11.70 1202.8 520.15
- age            1       25.72 1240.2 521.85
+ Mjob           4        4.02 1210.5 522.58
- famrel.x       1       37.02 1251.5 525.32
- absences.x     1       61.40 1275.9 532.69
- G2.x           1     1032.58 2247.1 748.89

Step:  AIC=514.2
G3.x ~ school + sex + age + address + Fedu + nursery + internet +
    guardian.x + traveltime.x + studytime.x + failures.x + schoolsup.x +
    famsup.x + activities.x + romantic.x + famrel.x + freetime.x +
    goout.x + Walc.x + health.x + absences.x + G1.x + G2.x +
    guardian.y + traveltime.y + studytime.y + failures.y + schoolsup.y +
    famsup.y + activities.y + romantic.y + absences.y + G2.y +
    G3.y

               Df Sum of Sq    RSS    AIC
- internet      1        1.33 1217.0 512.62
- G3.y          1        1.74 1217.4 512.75
- freetime.x    1        1.76 1217.4 512.76
- address       1        2.54 1218.2 513.00
- romantic.y    1        2.76 1218.4 513.07
- failures.x    1        2.83 1218.5 513.09
- Fedu          1        3.08 1218.7 513.17
- goout.x       1        3.10 1218.7 513.18
- nursery       1        3.32 1219.0 513.25
- Walc.x        1        3.41 1219.0 513.27
- romantic.x    1        3.89 1219.5 513.43
```

```
- school        1      3.97 1219.6 513.45
- failures.y    1      4.26 1219.9 513.54
- G2.y          1      4.79 1220.4 513.71
- sex           1      4.89 1220.5 513.74
- health.x      1      5.03 1220.7 513.78
<none>                 1215.6 514.20
- activities.y  1      6.55 1222.2 514.26
- schoolsup.y   1      6.91 1222.5 514.37
- activities.x  1      7.69 1223.3 514.61
- studytime.x   1      8.05 1223.7 514.73
- guardian.x    1      8.10 1223.7 514.74
- schoolsup.x   1      8.53 1224.2 514.88
- studytime.y   1      8.55 1224.2 514.88
- guardian.y    1      9.61 1225.2 515.21
+ Dalc.y        1      1.17 1214.5 515.84
+ Dalc.x        1      1.14 1214.5 515.85
- famsup.x      1     11.82 1227.5 515.90
+ Pstatus       1      0.82 1214.8 515.95
+ Medu          1      0.56 1215.1 516.03
- famsup.y      1     12.25 1227.9 516.03
+ higher.x      1      0.51 1215.1 516.04
+ famsize       1      0.43 1215.2 516.07
+ higher.y      1      0.42 1215.2 516.07
+ freetime.y    1      0.20 1215.4 516.14
+ goout.y       1      0.20 1215.4 516.14
+ health.y      1      0.20 1215.4 516.14
+ famrel.y      1      0.20 1215.4 516.14
+ paid.x        1      0.09 1215.5 516.18
+ paid.y        1      0.08 1215.6 516.18
+ G1.y          1      0.02 1215.6 516.20
+ reason        3     12.22 1203.4 516.35
- absences.y    1     18.24 1233.9 517.89
- G1.x          1     18.44 1234.1 517.96
- traveltime.y  1     19.18 1234.8 518.19
- traveltime.x  1     19.26 1234.9 518.21
+ Fjob          4     12.21 1203.4 518.35
- age           1     26.30 1241.9 520.38
+ Mjob          4      3.89 1211.7 520.98
- famrel.x      1     37.41 1253.0 523.78
- absences.x    1     61.49 1277.1 531.05
```

```
- G2.x          1   1032.12 2247.8 747.01

Step:  AIC=512.62
G3.x ~ school + sex + age + address + Fedu + nursery + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    activities.x + romantic.x + famrel.x + freetime.x + goout.x +
    Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + failures.y + schoolsup.y + famsup.y +
    activities.y + romantic.y + absences.y + G2.y + G3.y

                Df Sum of Sq    RSS    AIC
- G3.y           1      1.49 1218.5 511.09
- freetime.x     1      1.61 1218.6 511.13
- romantic.y     1      2.82 1219.8 511.51
- goout.x        1      2.92 1219.9 511.54
- nursery        1      3.07 1220.0 511.59
- failures.x     1      3.31 1220.3 511.66
- Walc.x         1      3.31 1220.3 511.66
- address        1      3.37 1220.3 511.68
- Fedu           1      3.41 1220.4 511.69
- school         1      3.82 1220.8 511.82
- romantic.x     1      4.02 1221.0 511.88
- sex            1      4.56 1221.5 512.05
- failures.y     1      4.88 1221.8 512.15
- G2.y           1      5.47 1222.5 512.34
- health.x       1      5.58 1222.5 512.37
<none>                       1217.0 512.62
- activities.y   1      6.51 1223.5 512.66
- schoolsup.y    1      6.92 1223.9 512.79
- activities.x   1      7.66 1224.6 513.02
- guardian.x     1      8.01 1225.0 513.13
- studytime.x    1      8.09 1225.1 513.15
- schoolsup.x    1      8.56 1225.5 513.30
- studytime.y    1      8.62 1225.6 513.32
- guardian.y     1      9.52 1226.5 513.60
+ internet       1      1.33 1215.6 514.20
+ Dalc.y         1      1.30 1215.7 514.21
+ Dalc.x         1      1.27 1215.7 514.22
+ Pstatus        1      0.98 1216.0 514.32
- famsup.x       1     11.84 1228.8 514.32
```

```
+ higher.x        1       0.61 1216.4 514.43
- famsup.y        1      12.24 1229.2 514.45
+ higher.y        1       0.53 1216.4 514.46
+ Medu            1       0.42 1216.5 514.49
+ famsize         1       0.39 1216.6 514.50
+ famrel.y        1       0.13 1216.8 514.58
+ freetime.y      1       0.13 1216.8 514.58
+ goout.y         1       0.13 1216.8 514.58
+ health.y        1       0.13 1216.8 514.58
+ paid.y          1       0.10 1216.9 514.59
+ G1.y            1       0.04 1216.9 514.61
+ paid.x          1       0.03 1217.0 514.62
+ reason          3      12.45 1204.5 514.70
- absences.y      1      18.40 1235.4 516.36
- G1.x            1      18.81 1235.8 516.48
+ Fjob            4      13.04 1203.9 516.51
- traveltime.y    1      19.07 1236.0 516.56
- traveltime.x    1      19.18 1236.2 516.60
- age             1      25.92 1242.9 518.68
+ Mjob            4       3.80 1213.2 519.43
- famrel.x        1      36.50 1253.5 521.91
- absences.x      1      60.42 1277.4 529.13
- G2.x            1    1035.55 2252.5 745.81

Step:  AIC=511.09
G3.x ~ school + sex + age + address + Fedu + nursery + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    activities.x + romantic.x + famrel.x + freetime.x + goout.x +
    Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + failures.y + schoolsup.y + famsup.y +
    activities.y + romantic.y + absences.y + G2.y
```

	Df	Sum of Sq	RSS	AIC
- freetime.x	1	1.58	1220.0	509.59
- goout.x	1	2.81	1221.3	509.97
- romantic.y	1	3.09	1221.5	510.06
- nursery	1	3.10	1221.6	510.06
- address	1	3.11	1221.6	510.06
- school	1	3.12	1221.6	510.07
- Walc.x	1	3.32	1221.8	510.13

```
- Fedu          1       3.60 1222.0 510.22
- failures.x    1       3.61 1222.1 510.22
- sex           1       4.13 1222.6 510.38
- failures.y    1       4.21 1222.7 510.41
- romantic.x    1       4.33 1222.8 510.45
- health.x      1       5.30 1223.8 510.75
<none>                       1218.5 511.09
- activities.y  1       6.69 1225.2 511.18
- schoolsup.y   1       6.83 1225.3 511.22
- guardian.x    1       7.79 1226.2 511.52
- activities.x  1       7.83 1226.3 511.54
- studytime.x   1       8.12 1226.6 511.63
- schoolsup.x   1       8.43 1226.9 511.72
- studytime.y   1       8.65 1227.1 511.79
- guardian.y    1       9.31 1227.8 512.00
+ G3.y          1       1.49 1217.0 512.62
+ Dalc.y        1       1.45 1217.0 512.64
+ Dalc.x        1       1.41 1217.0 512.65
+ Pstatus       1       1.12 1217.3 512.74
+ internet      1       1.08 1217.4 512.75
- famsup.x      1      11.81 1230.3 512.78
+ higher.x      1       0.73 1217.7 512.86
+ higher.y      1       0.62 1217.8 512.90
- famsup.y      1      12.24 1230.7 512.91
+ Medu          1       0.41 1218.0 512.96
+ famsize       1       0.36 1218.1 512.98
+ famrel.y      1       0.17 1218.3 513.04
+ freetime.y    1       0.17 1218.3 513.04
+ health.y      1       0.17 1218.3 513.04
+ goout.y       1       0.17 1218.3 513.04
+ paid.y        1       0.10 1218.4 513.06
+ paid.x        1       0.01 1218.5 513.09
+ G1.y          1       0.01 1218.5 513.09
+ reason        3      11.34 1207.1 513.52
- absences.y    1      17.42 1235.9 514.51
+ Fjob          4      12.83 1205.6 515.05
- traveltime.y  1      19.20 1237.7 515.06
- traveltime.x  1      19.41 1237.9 515.13
- G1.x          1      20.54 1239.0 515.48
- age           1      25.44 1243.9 516.98
```

```
- G2.y           1       27.08 1245.5 517.49
+ Mjob           4        3.44 1215.0 518.01
- famrel.x       1       37.28 1255.7 520.60
- absences.x     1       59.21 1277.7 527.22
- G2.x           1     1034.35 2252.8 743.86

Step:  AIC=509.59
G3.x ~ school + sex + age + address + Fedu + nursery + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    activities.x + romantic.x + famrel.x + goout.x + Walc.x +
    health.x + absences.x + G1.x + G2.x + guardian.y + traveltime.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + activities.y +
    romantic.y + absences.y + G2.y

                Df Sum of Sq    RSS    AIC
- romantic.y    1        2.93 1223.0 508.50
- nursery       1        3.03 1223.1 508.53
- address       1        3.06 1223.1 508.54
- Walc.x        1        3.31 1223.3 508.62
- school        1        3.44 1223.5 508.66
- failures.x    1        3.45 1223.5 508.66
- Fedu          1        3.93 1224.0 508.81
- romantic.x    1        4.11 1224.2 508.87
- failures.y    1        4.23 1224.3 508.91
- goout.x       1        4.37 1224.4 508.95
- sex           1        4.92 1225.0 509.12
- health.x      1        5.48 1225.5 509.30
<none>                        1220.0 509.59
- activities.y  1        6.49 1226.5 509.61
- schoolsup.y   1        6.77 1226.8 509.70
- activities.x  1        7.59 1227.6 509.95
- guardian.x    1        7.73 1227.8 510.00
- studytime.x   1        7.93 1228.0 510.06
- schoolsup.x   1        8.37 1228.4 510.20
- studytime.y   1        8.48 1228.5 510.23
- guardian.y    1        9.23 1229.3 510.47
+ freetime.x    1        1.58 1218.5 511.09
+ freetime.y    1        1.51 1218.5 511.11
+ G3.y          1        1.45 1218.6 511.13
- famsup.x      1       11.50 1231.5 511.17
```

```
+ Dalc.y          1       1.04 1219.0 511.26
+ Pstatus         1       1.03 1219.0 511.26
+ Dalc.x          1       1.00 1219.0 511.27
+ internet        1       0.95 1219.1 511.29
- famsup.y        1      11.94 1232.0 511.31
+ higher.x        1       0.76 1219.3 511.35
+ higher.y        1       0.63 1219.4 511.39
+ Medu            1       0.46 1219.6 511.44
+ famsize         1       0.39 1219.7 511.46
+ famrel.y        1       0.24 1219.8 511.51
+ goout.y         1       0.24 1219.8 511.51
+ health.y        1       0.24 1219.8 511.51
+ paid.y          1       0.14 1219.9 511.54
+ G1.y            1       0.01 1220.0 511.58
+ paid.x          1       0.00 1220.0 511.58
+ reason          3      11.72 1208.3 511.90
- absences.y      1      17.45 1237.5 513.01
+ Fjob            4      13.24 1206.8 513.42
- traveltime.y    1      19.62 1239.7 513.68
- traveltime.x    1      19.70 1239.7 513.71
- G1.x            1      21.46 1241.5 514.25
- age             1      26.30 1246.3 515.73
- G2.y            1      26.50 1246.5 515.79
+ Mjob            4       3.30 1216.7 516.55
- famrel.x        1      39.93 1260.0 519.89
- absences.x      1      58.44 1278.5 525.46
- G2.x            1    1032.99 2253.0 741.90

Step:  AIC=508.5
G3.x ~ school + sex + age + address + Fedu + nursery + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    activities.x + romantic.x + famrel.x + goout.x + Walc.x +
    health.x + absences.x + G1.x + G2.x + guardian.y + traveltime.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + activities.y +
    absences.y + G2.y

              Df Sum of Sq    RSS    AIC
- address      1       2.62 1225.6 507.32
- nursery      1       2.82 1225.8 507.38
- Walc.x       1       3.09 1226.1 507.47
```

```
- school        1        3.88 1226.8 507.71
- Fedu          1        3.91 1226.9 507.72
- failures.x    1        4.04 1227.0 507.76
- romantic.x    1        4.08 1227.0 507.77
- sex           1        4.44 1227.4 507.89
- goout.x       1        4.46 1227.4 507.89
- activities.y  1        4.81 1227.8 508.00
- failures.y    1        5.48 1228.5 508.21
- schoolsup.y   1        5.63 1228.6 508.26
- activities.x  1        5.77 1228.7 508.30
- health.x      1        6.41 1229.4 508.50
<none>                        1223.0 508.50
- schoolsup.x   1        7.08 1230.0 508.71
- studytime.x   1        7.51 1230.5 508.84
- studytime.y   1        8.04 1231.0 509.00
+ health.y      1        3.01 1220.0 509.56
+ romantic.y    1        2.93 1220.0 509.59
- guardian.x    1       10.26 1233.2 509.69
- famsup.x      1       10.86 1233.8 509.88
+ freetime.y    1        1.79 1221.2 509.94
+ G3.y          1        1.72 1221.2 509.96
- famsup.y      1       11.28 1234.2 510.01
+ freetime.x    1        1.42 1221.5 510.06
+ Dalc.x        1        1.17 1221.8 510.13
+ Pstatus       1        1.03 1221.9 510.18
+ internet      1        0.99 1222.0 510.19
+ higher.x      1        0.89 1222.1 510.22
+ Dalc.y        1        0.87 1222.1 510.23
- guardian.y    1       12.04 1235.0 510.24
+ higher.y      1        0.58 1222.4 510.32
+ goout.y       1        0.41 1222.5 510.37
+ Medu          1        0.41 1222.6 510.37
+ famsize       1        0.34 1222.6 510.40
+ paid.y        1        0.13 1222.8 510.46
+ G1.y          1        0.01 1223.0 510.50
+ famrel.y      1        0.00 1223.0 510.50
+ paid.x        1        0.00 1223.0 510.50
+ reason        3       11.56 1211.4 510.87
- traveltime.y  1       18.22 1241.2 512.15
- traveltime.x  1       18.37 1241.3 512.19
```

```
+ Fjob          4      13.21 1209.8 512.35
- absences.y    1      19.62 1242.6 512.58
- G1.x          1      21.46 1244.4 513.15
- G2.y          1      26.11 1249.1 514.57
- age           1      26.27 1249.2 514.62
+ Mjob          4       3.40 1219.6 515.44
- famrel.x      1      38.43 1261.4 518.32
- absences.x    1      61.71 1284.7 525.31
- G2.x          1    1030.30 2253.3 739.94

Step:  AIC=507.32
G3.x ~ school + sex + age + Fedu + nursery + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + activities.x +
    romantic.x + famrel.x + goout.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + activities.y + absences.y + G2.y

                Df Sum of Sq    RSS    AIC
- nursery       1       3.22 1228.8 506.32
- goout.x       1       3.48 1229.1 506.40
- Walc.x        1       3.74 1229.3 506.48
- Fedu          1       3.75 1229.3 506.49
- failures.x    1       3.84 1229.4 506.51
- sex           1       4.25 1229.8 506.64
- romantic.x    1       4.47 1230.1 506.71
- failures.y    1       5.10 1230.7 506.90
- activities.y  1       5.13 1230.7 506.91
- school        1       5.28 1230.9 506.96
- schoolsup.y   1       5.65 1231.2 507.08
- activities.x  1       6.07 1231.7 507.21
- health.x      1       6.38 1232.0 507.30
<none>                       1225.6 507.32
- schoolsup.x   1       7.11 1232.7 507.53
- studytime.x   1       7.77 1233.4 507.73
- studytime.y   1       8.26 1233.8 507.88
+ health.y      1       2.73 1222.8 508.47
+ address       1       2.62 1223.0 508.50
+ romantic.y    1       2.48 1223.1 508.54
- guardian.x    1      10.45 1236.0 508.56
- famsup.x      1      11.05 1236.6 508.75
```

```
+ freetime.y    1       1.72 1223.9 508.78
+ internet      1       1.64 1224.0 508.81
+ G3.y          1       1.43 1224.2 508.87
+ freetime.x    1       1.40 1224.2 508.88
- famsup.y      1      11.49 1237.1 508.88
+ Dalc.x        1       1.13 1224.5 508.97
+ Pstatus       1       0.97 1224.6 509.01
+ higher.x      1       0.88 1224.7 509.05
+ Dalc.y        1       0.86 1224.7 509.05
+ higher.y      1       0.57 1225.0 509.14
+ goout.y       1       0.49 1225.1 509.16
- guardian.y    1      12.42 1238.0 509.17
+ Medu          1       0.27 1225.3 509.24
+ famsize       1       0.21 1225.4 509.25
+ reason        3      12.94 1212.7 509.26
+ paid.y        1       0.05 1225.5 509.30
+ famrel.y      1       0.01 1225.6 509.32
+ paid.x        1       0.00 1225.6 509.32
+ G1.y          1       0.00 1225.6 509.32
+ Fjob          4      13.46 1212.1 511.10
- traveltime.y  1      19.12 1244.7 511.23
- absences.y    1      19.63 1245.2 511.39
- traveltime.x  1      19.85 1245.4 511.46
- G1.x          1      23.21 1248.8 512.49
- G2.y          1      24.15 1249.7 512.77
- age           1      24.93 1250.5 513.01
+ Mjob          4       3.29 1222.3 514.29
- famrel.x      1      38.72 1264.3 517.20
- absences.x    1      62.02 1287.6 524.18
- G2.x          1    1028.03 2253.6 738.00

Step:  AIC=506.32
G3.x ~ school + sex + age + Fedu + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + activities.x +
    romantic.x + famrel.x + goout.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + activities.y + absences.y + G2.y

             Df Sum of Sq    RSS    AIC
- goout.x         1       3.28 1232.1 505.34
```

```
- sex          1      3.97 1232.8 505.55
- failures.x   1      4.14 1233.0 505.60
- Walc.x       1      4.69 1233.5 505.77
- Fedu         1      4.71 1233.5 505.78
- romantic.x   1      4.73 1233.5 505.79
- activities.y 1      5.21 1234.0 505.94
- failures.y   1      5.23 1234.0 505.94
- schoolsup.y  1      5.65 1234.5 506.07
- school       1      5.87 1234.7 506.14
- activities.x 1      6.15 1235.0 506.23
<none>                     1228.8 506.32
- health.x     1      6.66 1235.5 506.38
- schoolsup.x  1      7.07 1235.9 506.51
- studytime.x  1      7.84 1236.6 506.75
- studytime.y  1      8.35 1237.2 506.91
+ nursery      1      3.22 1225.6 507.32
+ address      1      3.01 1225.8 507.38
+ health.y     1      2.51 1226.3 507.54
- guardian.x   1     10.64 1239.4 507.61
+ romantic.y   1      2.25 1226.5 507.62
- famsup.x     1     11.09 1239.9 507.75
+ freetime.y   1      1.63 1227.2 507.81
+ G3.y         1      1.43 1227.4 507.88
+ internet     1      1.42 1227.4 507.88
- famsup.y     1     11.52 1240.3 507.88
+ freetime.x   1      1.34 1227.5 507.90
+ Dalc.x       1      1.05 1227.8 507.99
+ higher.x     1      0.87 1227.9 508.05
+ Dalc.y       1      0.80 1228.0 508.07
+ Pstatus      1      0.80 1228.0 508.07
+ higher.y     1      0.57 1228.2 508.14
+ goout.y      1      0.48 1228.3 508.17
- guardian.y   1     12.54 1241.3 508.20
+ reason       3     12.93 1215.9 508.28
+ Medu         1      0.12 1228.7 508.28
+ paid.y       1      0.06 1228.7 508.30
+ famsize      1      0.05 1228.8 508.30
+ paid.x       1      0.05 1228.8 508.30
+ famrel.y     1      0.01 1228.8 508.32
+ G1.y         1      0.00 1228.8 508.32
```

```
+ Fjob         4     13.52 1215.3 510.09
- absences.y   1     19.67 1248.5 510.39
- traveltime.y 1     19.88 1248.7 510.45
- traveltime.x 1     20.54 1249.3 510.65
- G1.x         1     22.59 1251.4 511.28
- G2.y         1     24.70 1253.5 511.92
- age          1     25.85 1254.7 512.27
+ Mjob         4      3.85 1225.0 513.12
- famrel.x     1     38.86 1267.7 516.21
- absences.x   1     61.29 1290.1 522.91
- G2.x         1   1026.84 2255.6 736.34

Step:  AIC=505.34
G3.x ~ school + sex + age + Fedu + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + activities.x +
    romantic.x + famrel.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + activities.y + absences.y + G2.y

              Df Sum of Sq    RSS    AIC
- sex          1      3.68 1235.8 504.48
- failures.x   1      3.72 1235.8 504.49
- Fedu         1      4.14 1236.2 504.62
- failures.y   1      4.93 1237.0 504.86
- romantic.x   1      4.95 1237.0 504.87
- school       1      5.37 1237.5 505.00
- health.x     1      5.93 1238.0 505.17
- activities.y 1      6.25 1238.3 505.27
- schoolsup.y  1      6.34 1238.4 505.30
<none>                     1232.1 505.34
- activities.x 1      7.24 1239.3 505.58
- schoolsup.x  1      7.85 1239.9 505.76
- studytime.x  1      9.04 1241.1 506.13
- studytime.y  1      9.57 1241.7 506.29
+ goout.x      1      3.28 1228.8 506.32
+ nursery      1      3.02 1229.1 506.40
+ health.y     1      2.99 1229.1 506.41
+ freetime.y   1      2.95 1229.1 506.42
- Walc.x       1     10.23 1242.3 506.50
+ freetime.x   1      2.59 1229.5 506.53
```

```
+ goout.y        1        2.52 1229.6 506.55
+ romantic.y     1        2.40 1229.7 506.59
+ address        1        1.96 1230.1 506.73
+ G3.y           1        1.35 1230.7 506.92
- guardian.x     1       11.75 1243.8 506.96
+ internet       1        1.05 1231.0 507.01
+ Dalc.x         1        1.05 1231.0 507.01
+ higher.x       1        0.88 1231.2 507.06
+ Dalc.y         1        0.81 1231.3 507.09
+ Pstatus        1        0.81 1231.3 507.09
+ higher.y       1        0.52 1231.6 507.17
- famsup.x       1       12.47 1244.5 507.18
+ Medu           1        0.25 1231.8 507.26
+ famrel.y       1        0.09 1232.0 507.31
+ paid.x         1        0.08 1232.0 507.31
+ paid.y         1        0.07 1232.0 507.32
+ famsize        1        0.05 1232.0 507.32
- famsup.y       1       12.92 1245.0 507.32
+ G1.y           1        0.03 1232.0 507.33
+ reason         3       12.47 1219.6 507.45
- guardian.y     1       13.91 1246.0 507.63
+ Fjob           4       14.28 1217.8 508.89
- absences.y     1       18.90 1251.0 509.15
- traveltime.y   1       20.23 1252.3 509.56
- traveltime.x   1       20.83 1252.9 509.74
- G1.x           1       23.20 1255.3 510.46
- G2.y           1       24.21 1256.3 510.77
- age            1       24.28 1256.4 510.79
+ Mjob           4        4.08 1228.0 512.07
- famrel.x       1       42.89 1275.0 516.41
- absences.x     1       59.70 1291.8 521.41
- G2.x           1     1024.11 2256.2 734.44

Step:  AIC=504.48
G3.x ~ school + age + Fedu + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + activities.x + romantic.x +
    famrel.x + Walc.x + health.x + absences.x + G1.x + G2.x +
    guardian.y + traveltime.y + studytime.y + failures.y + schoolsup.y +
    famsup.y + activities.y + absences.y + G2.y
```

```
                Df Sum of Sq     RSS     AIC
- failures.x    1        3.64  1239.4  503.60
- Fedu          1        3.78  1239.5  503.64
- school        1        4.45  1240.2  503.85
- failures.y    1        5.05  1240.8  504.03
- romantic.x    1        5.49  1241.3  504.17
- schoolsup.y   1        6.21  1242.0  504.39
- activities.y  1        6.34  1242.1  504.43
<none>                         1235.8  504.48
- health.x      1        6.53  1242.3  504.49
- activities.x  1        7.25  1243.0  504.71
- schoolsup.x   1        7.58  1243.3  504.81
- studytime.x   1        8.72  1244.5  505.16
+ freetime.y    1        3.72  1232.0  505.33
+ sex           1        3.68  1232.1  505.34
- studytime.y   1        9.35  1245.1  505.36
+ freetime.x    1        3.34  1232.4  505.44
+ goout.x       1        2.99  1232.8  505.55
+ nursery       1        2.77  1233.0  505.62
+ health.y      1        2.55  1233.2  505.69
+ goout.y       1        2.31  1233.5  505.76
+ romantic.y    1        2.02  1233.7  505.85
+ address       1        1.83  1233.9  505.91
- guardian.x    1       11.65  1247.4  506.06
+ G3.y          1        0.95  1234.8  506.18
+ Pstatus       1        0.93  1234.8  506.19
+ internet      1        0.79  1235.0  506.23
- famsup.x      1       12.26  1248.0  506.25
+ Dalc.x        1        0.69  1235.1  506.26
+ Medu          1        0.61  1235.2  506.29
+ Dalc.y        1        0.52  1235.2  506.32
+ higher.x      1        0.49  1235.3  506.32
- famsup.y      1       12.67  1248.4  506.37
+ higher.y      1        0.25  1235.5  506.40
+ paid.x        1        0.19  1235.6  506.42
+ famsize       1        0.14  1235.6  506.43
+ famrel.y      1        0.09  1235.7  506.45
- Walc.x        1       12.93  1248.7  506.45
+ paid.y        1        0.01  1235.8  506.47
+ G1.y          1        0.00  1235.8  506.48
```

```
- guardian.y    1        13.76 1249.5 506.70
+ reason        3        10.74 1225.0 507.14
+ Fjob          4        14.81 1221.0 507.87
- absences.y    1        19.12 1254.9 508.34
- G2.y          1        20.85 1256.6 508.87
- traveltime.y  1        20.99 1256.8 508.91
- traveltime.x  1        21.66 1257.4 509.11
- age           1        23.76 1259.5 509.75
- G1.x          1        25.78 1261.5 510.36
+ Mjob          4         3.88 1231.9 511.28
- famrel.x      1        45.24 1281.0 516.21
- absences.x    1        56.92 1292.7 519.68
- G2.x          1      1039.47 2275.2 735.65

Step:  AIC=503.6
G3.x ~ school + age + Fedu + guardian.x + traveltime.x + studytime.x +
    schoolsup.x + famsup.x + activities.x + romantic.x + famrel.x +
    Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + failures.y + schoolsup.y + famsup.y +
    activities.y + absences.y + G2.y

                Df Sum of Sq    RSS    AIC
- failures.y    1         2.49 1241.9 502.36
- Fedu          1         3.03 1242.4 502.53
- school        1         5.07 1244.5 503.16
- romantic.x    1         6.15 1245.5 503.49
- health.x      1         6.42 1245.8 503.57
- schoolsup.y   1         6.49 1245.9 503.59
<none>                        1239.4 503.60
- activities.y  1         6.76 1246.2 503.68
- activities.x  1         7.70 1247.1 503.97
- schoolsup.x   1         7.93 1247.3 504.04
- studytime.x   1         9.21 1248.6 504.43
+ failures.x    1         3.64 1235.8 504.48
+ sex           1         3.60 1235.8 504.49
+ freetime.y    1         3.37 1236.0 504.56
- studytime.y   1         9.82 1249.2 504.61
+ health.y      1         3.07 1236.3 504.65
+ nursery       1         3.05 1236.3 504.66
+ freetime.x    1         2.96 1236.4 504.69
```

```
+ goout.x        1        2.60 1236.8 504.80
+ romantic.y     1        2.49 1236.9 504.83
+ goout.y        1        1.93 1237.5 505.00
+ address        1        1.73 1237.7 505.07
- guardian.x     1       11.57 1251.0 505.15
+ G3.y           1        1.23 1238.2 505.22
+ internet       1        1.15 1238.2 505.24
+ higher.x       1        1.13 1238.3 505.25
+ Pstatus        1        0.76 1238.6 505.37
+ higher.y       1        0.73 1238.7 505.37
+ Dalc.x         1        0.67 1238.7 505.39
+ Medu           1        0.62 1238.8 505.41
+ Dalc.y         1        0.48 1238.9 505.45
- Walc.x         1       12.67 1252.1 505.49
- famsup.x       1       12.88 1252.3 505.55
+ famsize        1        0.12 1239.3 505.56
+ famrel.y       1        0.08 1239.3 505.58
+ paid.x         1        0.07 1239.3 505.58
+ G1.y           1        0.02 1239.4 505.59
+ paid.y         1        0.00 1239.4 505.60
- famsup.y       1       13.32 1252.7 505.68
- guardian.y     1       13.80 1253.2 505.83
+ reason         3       11.03 1228.4 506.18
+ Fjob           4       16.34 1223.1 506.53
- traveltime.y   1       19.96 1259.4 507.70
- traveltime.x   1       20.57 1260.0 507.89
- G2.y           1       20.70 1260.1 507.93
- absences.y     1       21.37 1260.8 508.13
- age            1       23.31 1262.7 508.72
- G1.x           1       28.49 1267.9 510.28
+ Mjob           4        3.74 1235.7 510.44
- famrel.x       1       47.17 1286.6 515.87
- absences.x     1       59.34 1298.7 519.46
- G2.x           1     1056.01 2295.4 737.02

Step:  AIC=502.36
G3.x ~ school + age + Fedu + guardian.x + traveltime.x + studytime.x +
    schoolsup.x + famsup.x + activities.x + romantic.x + famrel.x +
    Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + schoolsup.y + famsup.y + activities.y +
```

```
       absences.y + G2.y

                Df Sum of Sq    RSS     AIC
- Fedu           1      4.21 1246.1 501.66
- school         1      4.58 1246.5 501.77
- schoolsup.y    1      6.51 1248.4 502.36
<none>                       1241.9 502.36
- romantic.x     1      6.74 1248.6 502.43
- health.x       1      6.82 1248.7 502.46
- activities.y   1      7.18 1249.1 502.57
- schoolsup.x    1      8.03 1249.9 502.83
- activities.x   1      8.13 1250.0 502.86
+ sex            1      3.72 1238.2 503.22
+ health.y       1      3.65 1238.2 503.24
+ freetime.y     1      3.53 1238.3 503.28
- studytime.x    1      9.57 1251.5 503.30
+ romantic.y     1      3.12 1238.8 503.40
+ freetime.x     1      3.04 1238.8 503.43
+ nursery        1      3.03 1238.8 503.43
- studytime.y    1     10.26 1252.1 503.51
+ goout.x        1      2.53 1239.4 503.59
+ failures.y     1      2.49 1239.4 503.60
+ goout.y        1      1.87 1240.0 503.79
+ address        1      1.56 1240.3 503.89
- guardian.x     1     11.51 1253.4 503.89
+ internet       1      1.45 1240.4 503.92
+ failures.x     1      1.08 1240.8 504.03
+ Pstatus        1      0.71 1241.2 504.15
+ G3.y           1      0.64 1241.2 504.17
+ higher.x       1      0.63 1241.2 504.17
+ Dalc.x         1      0.60 1241.3 504.18
+ Medu           1      0.51 1241.4 504.21
+ Dalc.y         1      0.39 1241.5 504.24
+ higher.y       1      0.34 1241.5 504.26
+ paid.x         1      0.22 1241.7 504.30
+ famsize        1      0.07 1241.8 504.34
+ famrel.y       1      0.04 1241.8 504.35
+ G1.y           1      0.03 1241.8 504.35
+ paid.y         1      0.03 1241.8 504.35
- Walc.x         1     13.41 1255.3 504.47
```

```
- famsup.x      1      13.43 1255.3 504.47
- guardian.y    1      13.78 1255.7 504.58
- famsup.y      1      13.92 1255.8 504.62
+ reason        3      10.73 1231.2 505.05
+ Fjob          4      16.63 1225.3 505.22
- traveltime.y  1      18.27 1260.2 505.94
- G2.y          1      18.35 1260.2 505.97
- traveltime.x  1      18.85 1260.7 506.12
- absences.y    1      20.50 1262.4 506.62
- age           1      20.86 1262.8 506.73
+ Mjob          4       3.80 1238.1 509.19
- G1.x          1      29.68 1271.6 509.39
- famrel.x      1      46.53 1288.4 514.42
- absences.x    1      57.65 1299.5 517.70
- G2.x          1    1063.51 2305.4 736.68

Step:  AIC=501.66
G3.x ~ school + age + guardian.x + traveltime.x + studytime.x +
    schoolsup.x + famsup.x + activities.x + romantic.x + famrel.x +
    Walc.x + health.x + absences.x + G1.x + G2.x + guardian.y +
    traveltime.y + studytime.y + schoolsup.y + famsup.y + activities.y +
    absences.y + G2.y

               Df Sum of Sq    RSS    AIC
- school        1       4.15 1250.2 500.93
<none>                       1246.1 501.66
- health.x      1       6.72 1252.8 501.71
- romantic.x    1       7.05 1253.2 501.81
- schoolsup.y   1       7.64 1253.7 501.99
- activities.y  1       8.26 1254.3 502.18
+ Fedu          1       4.21 1241.9 502.36
+ nursery       1       3.92 1242.2 502.45
+ freetime.y    1       3.89 1242.2 502.46
- schoolsup.x   1       9.22 1255.3 502.47
- activities.x  1       9.37 1255.5 502.52
+ failures.y    1       3.66 1242.4 502.53
+ health.y      1       3.60 1242.5 502.55
+ sex           1       3.36 1242.7 502.63
+ freetime.x    1       3.35 1242.7 502.63
+ romantic.y    1       3.19 1242.9 502.68
```

```
- studytime.x    1      10.79 1256.9 502.95
+ goout.x        1       2.07 1244.0 503.02
+ internet       1       1.80 1244.3 503.10
- studytime.y    1      11.46 1257.6 503.16
+ address        1       1.52 1244.6 503.19
+ goout.y        1       1.51 1244.6 503.19
- guardian.x     1      12.31 1258.4 503.41
+ Dalc.x         1       0.77 1245.3 503.42
+ G3.y           1       0.66 1245.4 503.46
- Walc.x         1      12.53 1258.6 503.48
+ Dalc.y         1       0.53 1245.6 503.50
+ Medu           1       0.48 1245.6 503.51
+ failures.x     1       0.43 1245.7 503.53
+ Pstatus        1       0.41 1245.7 503.53
+ higher.x       1       0.37 1245.7 503.54
+ paid.x         1       0.29 1245.8 503.57
+ higher.y       1       0.16 1245.9 503.61
+ famsize        1       0.13 1246.0 503.62
+ famrel.y       1       0.02 1246.1 503.65
+ G1.y           1       0.00 1246.1 503.66
+ paid.y         1       0.00 1246.1 503.66
- famsup.x       1      14.82 1260.9 504.17
- guardian.y     1      14.89 1261.0 504.20
- famsup.y       1      15.18 1261.3 504.28
+ Fjob           4      17.29 1228.8 504.32
+ reason         3      10.67 1235.4 504.37
- G2.y           1      17.04 1263.1 504.85
- traveltime.y   1      17.95 1264.0 505.12
- traveltime.x   1      18.91 1265.0 505.41
- age            1      19.61 1265.7 505.62
- absences.y     1      21.27 1267.4 506.12
- G1.x           1      27.11 1273.2 507.88
+ Mjob           4       5.56 1240.5 507.95
- famrel.x       1      46.19 1292.3 513.56
- absences.x     1      56.88 1303.0 516.71
- G2.x           1    1076.92 2323.0 737.59

Step:  AIC=500.93
G3.x ~ age + guardian.x + traveltime.x + studytime.x + schoolsup.x +
    famsup.x + activities.x + romantic.x + famrel.x + Walc.x +
```

```
       health.x + absences.x + G1.x + G2.x + guardian.y + traveltime.y +
       studytime.y + schoolsup.y + famsup.y + activities.y + absences.y +
       G2.y

                 Df Sum of Sq    RSS    AIC
- health.x        1      6.15 1256.4 500.80
<none>                        1250.2 500.93
- romantic.x      1      6.62 1256.9 500.95
- schoolsup.y     1      7.55 1257.8 501.23
- activities.y    1      8.07 1258.3 501.38
+ nursery         1      4.48 1245.8 501.55
+ freetime.y      1      4.17 1246.1 501.65
+ school          1      4.15 1246.1 501.66
- schoolsup.x     1      9.07 1259.3 501.69
- activities.x    1      9.21 1259.5 501.73
+ Fedu            1      3.78 1246.5 501.77
+ health.y        1      3.65 1246.6 501.81
+ romantic.y      1      3.55 1246.7 501.84
+ freetime.x      1      3.54 1246.7 501.84
+ failures.y      1      3.02 1247.2 502.00
+ address         1      2.60 1247.6 502.13
+ sex             1      2.51 1247.7 502.16
- studytime.x     1     10.71 1261.0 502.19
+ internet        1      1.91 1248.3 502.34
+ goout.x         1      1.75 1248.5 502.39
- studytime.y     1     11.41 1261.7 502.40
- Walc.x          1     11.47 1261.7 502.42
+ goout.y         1      1.33 1248.9 502.52
- guardian.x      1     12.02 1262.3 502.58
+ higher.x        1      0.81 1249.4 502.68
+ failures.x      1      0.75 1249.5 502.70
+ Dalc.x          1      0.67 1249.6 502.72
+ higher.y        1      0.51 1249.7 502.77
+ Medu            1      0.51 1249.7 502.77
+ Dalc.y          1      0.43 1249.8 502.80
+ Pstatus         1      0.29 1250.0 502.84
+ G3.y            1      0.23 1250.0 502.86
+ paid.x          1      0.17 1250.1 502.87
+ famsize         1      0.12 1250.1 502.89
+ G1.y            1      0.04 1250.2 502.91
```

```
+ paid.y         1        0.03 1250.2 502.92
+ famrel.y       1        0.00 1250.2 502.93
- guardian.y     1       14.51 1264.8 503.33
- famsup.x       1       14.79 1265.0 503.42
- famsup.y       1       15.09 1265.3 503.51
- G2.y           1       15.23 1265.5 503.55
+ reason         3       10.87 1239.4 503.59
- age            1       15.80 1266.0 503.72
- traveltime.y   1       16.96 1267.2 504.07
+ Fjob           4       15.49 1234.8 504.16
- traveltime.x   1       18.32 1268.6 504.48
- absences.y     1       22.43 1272.7 505.72
- G1.x           1       27.37 1277.6 507.20
+ Mjob           4        5.49 1244.8 507.25
- famrel.x       1       43.95 1294.2 512.12
- absences.x     1       54.72 1305.0 515.29
- G2.x           1     1084.72 2335.0 737.55

Step:  AIC=500.8
G3.x ~ age + guardian.x + traveltime.x + studytime.x + schoolsup.x +
    famsup.x + activities.x + romantic.x + famrel.x + Walc.x +
    absences.x + G1.x + G2.x + guardian.y + traveltime.y + studytime.y +
    schoolsup.y + famsup.y + activities.y + absences.y + G2.y

               Df Sum of Sq    RSS    AIC
- romantic.x    1        6.17 1262.6 500.67
<none>                        1256.4 500.80
+ health.x      1        6.15 1250.2 500.93
- schoolsup.y   1        7.47 1263.9 501.07
- activities.y  1        7.98 1264.4 501.22
+ health.y      1        4.94 1251.5 501.30
+ nursery       1        4.73 1251.7 501.36
+ romantic.y    1        4.48 1251.9 501.44
+ freetime.y    1        4.36 1252.0 501.47
- schoolsup.x   1        8.90 1265.3 501.50
- activities.x  1        9.09 1265.5 501.55
+ Fedu          1        3.72 1252.7 501.67
+ freetime.x    1        3.63 1252.8 501.70
+ school        1        3.57 1252.8 501.71
+ failures.y    1        3.47 1252.9 501.74
```

```
+ sex            1        3.06 1253.3 501.87
- studytime.x    1       10.32 1266.7 501.93
+ internet       1        2.61 1253.8 502.00
+ address        1        2.59 1253.8 502.01
- studytime.y    1       11.04 1267.4 502.14
+ goout.x        1        1.24 1255.2 502.42
- guardian.x     1       12.13 1268.5 502.47
+ goout.y        1        0.87 1255.5 502.54
+ higher.x       1        0.73 1255.7 502.58
+ Dalc.x         1        0.72 1255.7 502.58
- Walc.x         1       12.50 1268.9 502.58
- G2.y           1       12.52 1268.9 502.59
+ Medu           1        0.65 1255.7 502.60
+ failures.x     1        0.60 1255.8 502.62
+ Dalc.y         1        0.43 1256.0 502.67
+ higher.y       1        0.42 1256.0 502.67
+ paid.x         1        0.41 1256.0 502.68
+ Pstatus        1        0.24 1256.2 502.73
+ G3.y           1        0.13 1256.3 502.76
+ paid.y         1        0.08 1256.3 502.78
+ famsize        1        0.06 1256.3 502.78
+ G1.y           1        0.03 1256.4 502.79
+ famrel.y       1        0.01 1256.4 502.80
- guardian.y     1       14.51 1270.9 503.19
- famsup.x       1       14.54 1270.9 503.20
- famsup.y       1       14.90 1271.3 503.30
+ Fjob           4       16.86 1239.5 503.64
- traveltime.y   1       16.40 1272.8 503.76
+ reason         3        9.41 1247.0 503.93
- age            1       17.50 1273.9 504.09
- traveltime.x   1       17.66 1274.0 504.13
- absences.y     1       22.93 1279.3 505.71
+ Mjob           4        5.58 1250.8 507.10
- G1.x           1       29.20 1285.6 507.58
- famrel.x       1       48.12 1304.5 513.16
- absences.x     1       54.15 1310.5 514.92
- G2.x           1     1079.27 2335.7 735.66

Step:  AIC=500.67
G3.x ~ age + guardian.x + traveltime.x + studytime.x + schoolsup.x +
```

```
        famsup.x + activities.x + famrel.x + Walc.x + absences.x +
        G1.x + G2.x + guardian.y + traveltime.y + studytime.y + schoolsup.y +
        famsup.y + activities.y + absences.y + G2.y

                    Df Sum of Sq      RSS     AIC
<none>                          1262.6 500.67
+ romantic.x    1        6.17 1256.4 500.80
- schoolsup.y   1        7.33 1269.9 500.88
+ health.x      1        5.70 1256.9 500.95
- activities.y  1        7.77 1270.3 501.01
+ nursery       1        5.08 1257.5 501.13
- schoolsup.x   1        8.82 1271.4 501.33
+ health.y      1        4.40 1258.2 501.34
- activities.x  1        8.90 1271.5 501.36
+ romantic.y    1        4.34 1258.2 501.36
+ failures.y    1        4.18 1258.4 501.41
+ freetime.y    1        4.16 1258.4 501.41
+ Fedu          1        4.02 1258.5 501.45
+ sex           1        3.60 1259.0 501.58
+ internet      1        3.43 1259.1 501.63
+ freetime.x    1        3.36 1259.2 501.66
+ school        1        3.21 1259.3 501.70
- studytime.x   1       10.16 1272.7 501.73
+ address       1        2.90 1259.7 501.79
- studytime.y   1       10.90 1273.5 501.96
+ goout.x       1        1.37 1261.2 502.26
+ higher.x      1        1.32 1261.2 502.27
+ Dalc.x        1        1.00 1261.6 502.37
+ goout.y       1        0.95 1261.6 502.38
+ higher.y      1        0.86 1261.7 502.41
+ Medu          1        0.83 1261.7 502.42
+ failures.x    1        0.69 1261.9 502.46
- guardian.x    1       12.66 1275.2 502.48
+ Dalc.y        1        0.61 1262.0 502.49
- Walc.x        1       12.79 1275.3 502.52
+ paid.x        1        0.49 1262.1 502.52
- G2.y          1       13.07 1275.6 502.61
+ Pstatus       1        0.11 1262.5 502.64
+ G3.y          1        0.10 1262.5 502.64
+ G1.y          1        0.08 1262.5 502.65
```

```
+ paid.y        1       0.07 1262.5 502.65
+ famrel.y      1       0.02 1262.5 502.67
+ famsize       1       0.01 1262.5 502.67
- famsup.x      1      14.59 1277.2 503.06
- famsup.y      1      14.92 1277.5 503.16
- guardian.y    1      15.14 1277.7 503.23
+ Fjob          4      17.68 1244.9 503.29
- traveltime.y  1      16.03 1278.6 503.49
- traveltime.x  1      17.38 1279.9 503.89
+ reason        3       8.92 1253.6 503.96
- age           1      19.18 1281.7 504.43
- absences.y    1      22.02 1284.6 505.28
- G1.x          1      26.47 1289.0 506.60
+ Mjob          4       5.07 1257.5 507.13
- absences.x    1      50.89 1313.5 513.77
- famrel.x      1      51.20 1313.8 513.86
- G2.x          1    1132.45 2395.0 743.25

Call:
lm(formula = G3.x ~ age + guardian.x + traveltime.x + studytime.x +
    schoolsup.x + famsup.x + activities.x + famrel.x + Walc.x +
    absences.x + G1.x + G2.x + guardian.y + traveltime.y + studytime.y +
    schoolsup.y + famsup.y + activities.y + absences.y + G2.y,
    data = data)

Coefficients:
    (Intercept)              age  guardian.xmother  guardian.xother
       -1.24333         -0.21277          -3.87959          0.11859
    traveltime.x      studytime.x    schoolsup.xyes      famsup.xyes
        2.75836          4.91618           5.87810         -9.70780
  activities.xyes         famrel.x            Walc.x       absences.x
       -6.14135          0.40737           0.15800          0.05756
           G1.x             G2.x  guardian.ymother  guardian.yother
        0.16538          0.93793           4.24692               NA
    traveltime.y      studytime.y    schoolsup.yyes      famsup.yyes
       -2.63578         -5.09303          -5.38131          9.83361
  activities.yyes       absences.y              G2.y
        5.74082         -0.05944           0.10228
```

```
stepAIC_x <- stepAIC
```

```
stepAIC(modreg_trein_y, direction="both", keep=NULL)
```

Start: AIC=233.6
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
    higher.y + romantic.y + famrel.y + freetime.y + goout.y +
    Dalc.y + Walc.y + health.y + absences.y + G1.y + G2.y

Step: AIC=233.6
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
    higher.y + romantic.y + famrel.y + freetime.y + goout.y +
    Dalc.y + Walc.y + absences.y + G1.y + G2.y

Step: AIC=233.6
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
    higher.y + romantic.y + famrel.y + freetime.y + goout.y +
```

```
    Dalc.y + absences.y + G1.y + G2.y


Step:  AIC=233.6
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
    higher.y + romantic.y + famrel.y + freetime.y + goout.y +
    absences.y + G1.y + G2.y


Step:  AIC=233.6
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
    higher.y + romantic.y + famrel.y + freetime.y + absences.y +
    G1.y + G2.y


Step:  AIC=233.6
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
    higher.y + romantic.y + famrel.y + absences.y + G1.y + G2.y


Step:  AIC=233.6
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
```

```
Fedu + Mjob + Fjob + reason + nursery + internet + guardian.x +
traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
paid.x + activities.x + higher.x + romantic.x + famrel.x +
freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
higher.y + romantic.y + absences.y + G1.y + G2.y
```

	Df	Sum of Sq	RSS	AIC
- Fjob	4	6.117	531.30	230.03
- nursery	1	0.000	525.18	231.60
- activities.y	1	0.064	525.25	231.65
- paid.y	1	0.084	525.27	231.66
- activities.x	1	0.084	525.27	231.66
- Fedu	1	0.101	525.29	231.67
- traveltime.y	1	0.160	525.34	231.72
- freetime.x	1	0.250	525.43	231.78
- studytime.x	1	0.253	525.44	231.79
- studytime.y	1	0.259	525.44	231.79
- Walc.x	1	0.296	525.48	231.82
- Dalc.x	1	0.323	525.51	231.84
- traveltime.x	1	0.408	525.59	231.90
- famsup.y	1	0.422	525.61	231.91
- famsup.x	1	0.451	525.64	231.93
- higher.y	1	0.470	525.65	231.94
- romantic.x	1	0.567	525.75	232.01
- schoolsup.y	1	0.588	525.77	232.03
- schoolsup.x	1	0.631	525.82	232.06
- higher.x	1	0.755	525.94	232.15
- address	1	0.868	526.05	232.23
- romantic.y	1	0.871	526.06	232.23
- goout.x	1	0.876	526.06	232.24
- G2.x	1	0.884	526.07	232.24
- guardian.y	1	0.927	526.11	232.28
- guardian.x	1	1.008	526.19	232.33
- G3.x	1	1.412	526.60	232.63
- famrel.x	1	1.568	526.75	232.74
- paid.x	1	1.952	527.14	233.02
- Medu	1	1.989	527.17	233.05
- health.x	1	2.285	527.47	233.26

```
- G1.x          1      2.373 527.56 233.32
- internet      1      2.512 527.70 233.42
<none>                       525.18 233.60
- famsize       1      2.938 528.12 233.73
- age           1      3.155 528.34 233.89
- failures.x    1      4.175 529.36 234.63
- Pstatus       1      4.266 529.45 234.69
- sex           1      4.634 529.82 234.96
- reason        3     11.412 536.60 235.81
- absences.x    1      6.493 531.68 236.30
- Mjob          4     15.351 540.54 236.61
- absences.y    1      7.288 532.47 236.87
- G1.y          1      7.784 532.97 237.22
- failures.y    1      8.800 533.98 237.95
- school        1     14.117 539.30 241.73
- G2.y          1    230.355 755.54 370.53

Step:  AIC=230.03
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + nursery + internet + guardian.x +
    traveltime.x + studytime.x + failures.x + schoolsup.x + famsup.x +
    paid.x + activities.x + higher.x + romantic.x + famrel.x +
    freetime.x + goout.x + Dalc.x + Walc.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + traveltime.y + studytime.y +
    failures.y + schoolsup.y + famsup.y + paid.y + activities.y +
    higher.y + romantic.y + absences.y + G1.y + G2.y

                 Df Sum of Sq    RSS    AIC
- nursery        1      0.014 531.32 228.04
- freetime.x     1      0.058 531.36 228.07
- activities.y   1      0.083 531.38 228.08
- activities.x   1      0.110 531.41 228.10
- paid.y         1      0.122 531.42 228.11
- traveltime.y   1      0.194 531.49 228.16
- studytime.x    1      0.292 531.59 228.24
- studytime.y    1      0.299 531.60 228.24
- Walc.x         1      0.358 531.66 228.28
- Dalc.x         1      0.362 531.66 228.29
- traveltime.x   1      0.423 531.72 228.33
- famsup.y       1      0.471 531.77 228.36
```

```
- higher.y      1      0.500 531.80 228.38
- famsup.x      1      0.505 531.81 228.39
- romantic.x    1      0.577 531.88 228.44
- schoolsup.y   1      0.670 531.97 228.51
- Fedu          1      0.687 531.99 228.52
- schoolsup.x   1      0.725 532.03 228.55
- higher.x      1      0.820 532.12 228.61
- address       1      0.835 532.14 228.63
- romantic.y    1      0.883 532.18 228.66
- guardian.y    1      1.001 532.30 228.74
- G2.x          1      1.095 532.40 228.81
- guardian.x    1      1.097 532.40 228.81
- goout.x       1      1.171 532.47 228.87
- famrel.x      1      1.339 532.64 228.99
- G3.x          1      1.495 532.80 229.10
- Medu          1      1.742 533.04 229.28
- paid.x        1      1.913 533.21 229.40
- famsize       1      2.265 533.57 229.65
- G1.x          1      2.620 533.92 229.90
- health.x      1      2.648 533.95 229.92
<none>                       531.30 230.03
- internet      1      3.457 534.76 230.50
- age           1      3.580 534.88 230.59
- Pstatus       1      4.325 535.63 231.12
- failures.x    1      4.554 535.85 231.29
- sex           1      4.976 536.28 231.59
- Mjob          4     14.792 546.09 232.52
- G1.y          1      7.206 538.51 233.17
- absences.x    1      7.318 538.62 233.25
- absences.y    1      7.800 539.10 233.59
+ Fjob          4      6.117 525.18 233.60
- reason        3     13.983 545.28 233.95
- failures.y    1      9.001 540.30 234.44
- school        1     13.653 544.95 237.72
- G2.y          1    233.935 765.24 367.40

Step:  AIC=228.04
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
```

129

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    activities.x + higher.x + romantic.x + famrel.x + freetime.x +
    goout.x + Dalc.x + Walc.x + health.x + absences.x + G1.x +
    G2.x + G3.x + guardian.y + traveltime.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + paid.y + activities.y + higher.y +
    romantic.y + absences.y + G1.y + G2.y
```

	Df	Sum of Sq	RSS	AIC
- freetime.x	1	0.056	531.37	226.08
- activities.y	1	0.084	531.40	226.10
- activities.x	1	0.110	531.43	226.11
- paid.y	1	0.121	531.44	226.12
- traveltime.y	1	0.191	531.51	226.17
- studytime.x	1	0.294	531.61	226.25
- studytime.y	1	0.301	531.62	226.25
- Walc.x	1	0.348	531.66	226.29
- Dalc.x	1	0.367	531.68	226.30
- traveltime.x	1	0.420	531.74	226.34
- famsup.y	1	0.473	531.79	226.38
- higher.y	1	0.502	531.82	226.40
- famsup.x	1	0.507	531.82	226.40
- romantic.x	1	0.584	531.90	226.45
- schoolsup.y	1	0.671	531.99	226.52
- Fedu	1	0.679	531.99	226.52
- schoolsup.x	1	0.726	532.04	226.56
- higher.x	1	0.822	532.14	226.63
- address	1	0.848	532.16	226.64
- romantic.y	1	0.892	532.21	226.68
- guardian.y	1	1.004	532.32	226.76
- G2.x	1	1.087	532.40	226.82
- guardian.x	1	1.101	532.42	226.83
- goout.x	1	1.166	532.48	226.87
- famrel.x	1	1.343	532.66	227.00
- G3.x	1	1.484	532.80	227.10
- Medu	1	1.730	533.05	227.28
- paid.x	1	1.898	533.21	227.40
- famsize	1	2.255	533.57	227.65
- G1.x	1	2.654	533.97	227.94
- health.x	1	2.659	533.98	227.94
<none>			531.32	228.04
- internet	1	3.444	534.76	228.50

```
- age           1     3.603 534.92 228.62
- Pstatus       1     4.346 535.66 229.15
- failures.x    1     4.539 535.86 229.29
- sex           1     4.968 536.28 229.59
+ nursery       1     0.014 531.30 230.03
- Mjob          4    14.910 546.23 230.61
- G1.y          1     7.192 538.51 231.17
- absences.x    1     7.310 538.63 231.26
+ Fjob          4     6.131 525.18 231.60
- absences.y    1     7.825 539.14 231.62
- reason        3    13.980 545.30 231.96
- failures.y    1     9.016 540.33 232.46
- school        1    13.750 545.07 235.80
- G2.y          1   233.963 765.28 365.42

Step:  AIC=226.08
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
    activities.x + higher.x + romantic.x + famrel.x + goout.x +
    Dalc.x + Walc.x + health.x + absences.x + G1.x + G2.x + G3.x +
    guardian.y + traveltime.y + studytime.y + failures.y + schoolsup.y +
    famsup.y + paid.y + activities.y + higher.y + romantic.y +
    absences.y + G1.y + G2.y

                 Df Sum of Sq    RSS    AIC
- activities.y  1     0.075 531.45 224.13
- activities.x  1     0.100 531.47 224.15
- paid.y        1     0.116 531.49 224.16
- traveltime.y  1     0.179 531.55 224.20
- studytime.x   1     0.279 531.65 224.28
- studytime.y   1     0.287 531.66 224.28
- Walc.x        1     0.373 531.75 224.34
- traveltime.x  1     0.406 531.78 224.37
- Dalc.x        1     0.416 531.79 224.37
- famsup.y      1     0.454 531.83 224.40
- higher.y      1     0.485 531.86 224.42
- famsup.x      1     0.487 531.86 224.43
- romantic.x    1     0.609 531.98 224.51
- schoolsup.y   1     0.654 532.03 224.55
```

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- Fedu           1      0.657 532.03 224.55
- schoolsup.x    1      0.708 532.08 224.58
- higher.x       1      0.799 532.17 224.65
- address        1      0.842 532.21 224.68
- romantic.y     1      0.921 532.29 224.74
- guardian.y     1      0.981 532.35 224.78
- G2.x           1      1.069 532.44 224.84
- guardian.x     1      1.077 532.45 224.85
- famrel.x       1      1.297 532.67 225.01
- goout.x        1      1.398 532.77 225.08
- G3.x           1      1.465 532.84 225.13
- Medu           1      1.719 533.09 225.31
- paid.x         1      1.867 533.24 225.42
- famsize        1      2.265 533.64 225.70
- G1.x           1      2.616 533.99 225.95
- health.x       1      2.678 534.05 226.00
<none>                  531.37 226.08
- internet       1      3.420 534.79 226.53
- age            1      3.668 535.04 226.70
- Pstatus        1      4.398 535.77 227.22
- failures.x     1      4.608 535.98 227.37
- sex            1      5.135 536.51 227.75
+ freetime.y     1      0.056 531.32 228.04
+ freetime.x     1      0.056 531.32 228.04
+ nursery        1      0.013 531.36 228.07
- Mjob           4     14.890 546.26 228.63
- G1.y           1      7.230 538.60 229.24
- absences.x     1      7.272 538.64 229.27
- absences.y     1      7.829 539.20 229.66
+ Fjob           4      5.937 525.44 229.78
- reason         3     14.068 545.44 230.06
- failures.y     1      9.016 540.39 230.50
- school         1     13.908 545.28 233.95
- G2.y           1    234.011 765.38 363.47

Step:  AIC=224.13
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
    activities.x + higher.x + romantic.x + famrel.x + goout.x +
```

```
     Dalc.x + Walc.x + health.x + absences.x + G1.x + G2.x + G3.x +
     guardian.y + traveltime.y + studytime.y + failures.y + schoolsup.y +
     famsup.y + paid.y + higher.y + romantic.y + absences.y +
     G1.y + G2.y

                 Df Sum of Sq    RSS    AIC
- paid.y         1      0.092 531.54 222.20
- traveltime.y   1      0.129 531.58 222.22
- traveltime.x   1      0.340 531.79 222.37
- Walc.x         1      0.390 531.84 222.41
- Dalc.x         1      0.424 531.87 222.43
- Fedu           1      0.647 532.09 222.59
- higher.y       1      0.791 532.24 222.70
- address        1      0.831 532.28 222.73
- romantic.x     1      1.011 532.46 222.86
- G2.x           1      1.072 532.52 222.90
- goout.x        1      1.368 532.82 223.11
- famrel.x       1      1.403 532.85 223.14
- romantic.y     1      1.448 532.90 223.17
- G3.x           1      1.453 532.90 223.17
- studytime.x    1      1.586 533.03 223.27
- higher.x       1      1.615 533.06 223.29
- studytime.y    1      1.670 533.12 223.33
- Medu           1      1.728 533.18 223.37
- paid.x         1      1.890 533.34 223.49
- famsize        1      2.287 533.73 223.77
- activities.x   1      2.550 534.00 223.96
- G1.x           1      2.623 534.07 224.01
- health.x       1      2.683 534.13 224.05
<none>                        531.45 224.13
- schoolsup.y    1      3.093 534.54 224.35
- internet       1      3.487 534.93 224.63
- schoolsup.x    1      3.523 534.97 224.65
- age            1      3.705 535.15 224.78
- famsup.y       1      3.796 535.24 224.85
- guardian.y     1      3.978 535.43 224.98
- famsup.x       1      4.228 535.68 225.16
- Pstatus        1      4.390 535.84 225.27
- guardian.x     1      4.474 535.92 225.33
- failures.x     1      4.611 536.06 225.43
```

```
- sex             1      5.187 536.63 225.84
+ famrel.y        1      0.075 531.37 226.08
+ goout.y         1      0.075 531.37 226.08
+ activities.y    1      0.075 531.37 226.08
+ Dalc.y          1      0.075 531.37 226.08
+ Walc.y          1      0.075 531.37 226.08
+ freetime.y      1      0.060 531.39 226.09
+ freetime.x      1      0.048 531.40 226.10
+ nursery         1      0.014 531.43 226.12
- Mjob            4     14.975 546.42 226.75
- absences.x      1      7.252 538.70 227.31
- G1.y            1      7.336 538.78 227.37
- absences.y      1      7.760 539.21 227.67
+ Fjob            4      5.965 525.48 227.82
- reason          3     14.052 545.50 228.10
- failures.y      1      9.135 540.58 228.64
- school          1     14.171 545.62 232.18
- G2.y            1    233.936 765.38 361.47

Step:  AIC=222.2
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
    activities.x + higher.x + romantic.x + famrel.x + goout.x +
    Dalc.x + Walc.x + health.x + absences.x + G1.x + G2.x + G3.x +
    guardian.y + traveltime.y + studytime.y + failures.y + schoolsup.y +
    famsup.y + higher.y + romantic.y + absences.y + G1.y + G2.y

                 Df Sum of Sq    RSS    AIC
- traveltime.y  1      0.136 531.68 220.29
- traveltime.x  1      0.353 531.89 220.45
- Walc.x        1      0.406 531.95 220.49
- Dalc.x        1      0.456 532.00 220.52
- Fedu          1      0.674 532.21 220.68
- higher.y      1      0.809 532.35 220.78
- address       1      0.897 532.44 220.84
- romantic.x    1      0.983 532.52 220.90
- G2.x          1      1.093 532.63 220.98
- famrel.x      1      1.351 532.89 221.17
- goout.x       1      1.362 532.90 221.17
```

```
- romantic.y     1      1.415 532.95 221.21
- G3.x           1      1.455 532.99 221.24
- higher.x       1      1.639 533.18 221.37
- studytime.x    1      1.684 533.22 221.40
- studytime.y    1      1.767 533.31 221.46
- Medu           1      1.832 533.37 221.51
- paid.x         1      1.948 533.49 221.59
- famsize        1      2.294 533.83 221.84
- activities.x   1      2.489 534.03 221.98
- G1.x           1      2.700 534.24 222.13
- health.x       1      2.719 534.26 222.15
<none>                        531.54 222.20
- schoolsup.y    1      3.150 534.69 222.45
- internet       1      3.452 534.99 222.67
- schoolsup.x    1      3.585 535.12 222.76
- famsup.y       1      3.857 535.40 222.96
- age            1      3.868 535.41 222.97
- guardian.y     1      3.932 535.47 223.01
- famsup.x       1      4.282 535.82 223.26
- Pstatus        1      4.369 535.91 223.32
- guardian.x     1      4.418 535.96 223.36
- failures.x     1      4.594 536.13 223.48
- sex            1      5.379 536.92 224.04
+ paid.y         1      0.092 531.45 224.13
+ freetime.y     1      0.054 531.48 224.16
+ activities.y   1      0.052 531.49 224.16
+ famrel.y       1      0.052 531.49 224.16
+ goout.y        1      0.052 531.49 224.16
+ Dalc.y         1      0.052 531.49 224.16
+ Walc.y         1      0.052 531.49 224.16
+ freetime.x     1      0.044 531.49 224.16
+ nursery        1      0.013 531.53 224.19
- Mjob           4     14.951 546.49 224.79
- absences.x     1      7.344 538.88 225.44
- G1.y           1      7.366 538.91 225.45
- absences.y     1      7.939 539.48 225.86
+ Fjob           4      5.996 525.54 225.86
- reason         3     13.967 545.51 226.10
- failures.y     1      9.590 541.13 227.03
- school         1     14.512 546.05 230.49
```

```
- G2.y           1   233.990 765.53 359.55

Step:  AIC=220.29
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
    activities.x + higher.x + romantic.x + famrel.x + goout.x +
    Dalc.x + Walc.x + health.x + absences.x + G1.x + G2.x + G3.x +
    guardian.y + studytime.y + failures.y + schoolsup.y + famsup.y +
    higher.y + romantic.y + absences.y + G1.y + G2.y

                Df Sum of Sq    RSS    AIC
- Walc.x         1     0.418 532.09 218.59
- Dalc.x         1     0.477 532.15 218.64
- Fedu           1     0.682 532.36 218.78
- higher.y       1     0.683 532.36 218.78
- address        1     0.860 532.53 218.91
- romantic.x     1     0.930 532.61 218.96
- G2.x           1     1.146 532.82 219.12
- goout.x        1     1.315 532.99 219.24
- romantic.y     1     1.353 533.03 219.26
- famrel.x       1     1.392 533.07 219.29
- higher.x       1     1.505 533.18 219.37
- studytime.x    1     1.579 533.25 219.43
- G3.x           1     1.607 533.28 219.45
- studytime.y    1     1.668 533.34 219.49
- Medu           1     1.807 533.48 219.59
- paid.x         1     1.962 533.64 219.70
- famsize        1     2.278 533.95 219.93
- activities.x   1     2.432 534.11 220.04
- G1.x           1     2.696 534.37 220.23
- health.x       1     2.720 534.40 220.24
<none>                       531.68 220.29
- schoolsup.y    1     3.096 534.77 220.51
- internet       1     3.519 535.19 220.81
- schoolsup.x    1     3.567 535.24 220.85
- traveltime.x   1     3.733 535.41 220.97
- guardian.y     1     3.879 535.55 221.07
- age            1     3.889 535.56 221.08
- famsup.y       1     4.153 535.83 221.27
```

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- guardian.x    1      4.355 536.03 221.41
- Pstatus       1      4.358 536.03 221.41
- failures.x    1      4.566 536.24 221.56
- famsup.x      1      4.638 536.31 221.61
- sex           1      5.347 537.02 222.12
+ famrel.y      1      0.171 531.50 222.17
+ goout.y       1      0.140 531.53 222.19
+ health.y      1      0.136 531.54 222.20
+ traveltime.y  1      0.136 531.54 222.20
+ paid.y        1      0.098 531.58 222.22
+ freetime.y    1      0.063 531.61 222.25
+ freetime.x    1      0.038 531.64 222.27
+ Walc.y        1      0.032 531.64 222.27
+ activities.y  1      0.012 531.66 222.28
+ Dalc.y        1      0.012 531.66 222.28
+ nursery       1      0.011 531.66 222.29
- Mjob          4     15.005 546.68 222.93
- absences.x    1      7.256 538.93 223.47
- G1.y          1      7.396 539.07 223.57
- absences.y    1      7.859 539.53 223.90
+ Fjob          4      6.025 525.65 223.94
- reason        3     13.946 545.62 224.18
- failures.y    1      9.993 541.67 225.41
- school        1     14.800 546.47 228.78
- G2.y          1    233.866 765.54 357.55

Step:  AIC=218.59
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
    activities.x + higher.x + romantic.x + famrel.x + goout.x +
    Dalc.x + health.x + absences.x + G1.x + G2.x + G3.x + guardian.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + higher.y +
    romantic.y + absences.y + G1.y + G2.y

              Df Sum of Sq    RSS    AIC
- Dalc.x       1     0.163 532.26 216.71
- Fedu         1     0.613 532.71 217.03
- higher.y     1     0.636 532.73 217.05
- address      1     0.787 532.88 217.16
```

```
- romantic.x     1      0.937 533.03 217.27
- goout.x        1      0.969 533.06 217.29
- G2.x           1      1.142 533.23 217.41
- famrel.x       1      1.211 533.30 217.46
- romantic.y     1      1.360 533.45 217.57
- higher.x       1      1.445 533.54 217.63
- studytime.x    1      1.487 533.58 217.66
- studytime.y    1      1.554 533.65 217.71
- G3.x           1      1.732 533.82 217.84
- paid.x         1      1.796 533.89 217.88
- Medu           1      2.046 534.14 218.06
- famsize        1      2.244 534.34 218.20
- activities.x   1      2.376 534.47 218.30
- G1.x           1      2.499 534.59 218.38
- health.x       1      2.606 534.70 218.46
<none>                        532.09 218.59
- schoolsup.y    1      3.150 535.24 218.85
- internet       1      3.487 535.58 219.09
- schoolsup.x    1      3.686 535.78 219.23
- guardian.y     1      3.775 535.87 219.29
- traveltime.x   1      3.850 535.94 219.35
- famsup.y       1      3.930 536.02 219.41
- age            1      3.974 536.07 219.44
- Pstatus        1      4.221 536.31 219.61
- guardian.x     1      4.236 536.33 219.62
- famsup.x       1      4.387 536.48 219.73
- failures.x     1      4.530 536.62 219.83
- sex            1      5.065 537.16 220.21
+ Walc.x         1      0.418 531.68 220.29
+ Walc.y         1      0.382 531.71 220.32
+ famrel.y       1      0.196 531.90 220.45
+ goout.y        1      0.164 531.93 220.48
+ traveltime.y   1      0.147 531.95 220.49
+ health.y       1      0.147 531.95 220.49
+ paid.y         1      0.116 531.98 220.51
+ freetime.y     1      0.091 532.00 220.53
+ freetime.x     1      0.058 532.04 220.55
+ activities.y   1      0.017 532.08 220.58
+ Dalc.y         1      0.017 532.08 220.58
+ nursery        1      0.002 532.09 220.59
```

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- absences.x    1      6.912 539.00 221.52
- Mjob          4     15.594 547.69 221.63
- G1.y          1      7.367 539.46 221.85
- absences.y    1      7.805 539.90 222.16
+ Fjob          4      6.061 526.03 222.22
- reason        3     13.971 546.06 222.49
- failures.y    1      9.894 541.99 223.63
- school        1     15.183 547.28 227.34
- G2.y          1    234.699 766.79 356.18

Step:  AIC=216.71
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Fedu + Mjob + reason + internet + guardian.x + traveltime.x +
    studytime.x + failures.x + schoolsup.x + famsup.x + paid.x +
    activities.x + higher.x + romantic.x + famrel.x + goout.x +
    health.x + absences.x + G1.x + G2.x + G3.x + guardian.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + higher.y +
    romantic.y + absences.y + G1.y + G2.y

                Df Sum of Sq    RSS    AIC
- Fedu          1      0.611 532.87 215.15
- higher.y      1      0.675 532.93 215.20
- address       1      0.858 533.11 215.33
- romantic.x    1      0.980 533.24 215.41
- G2.x          1      1.201 533.46 215.57
- goout.x       1      1.263 533.52 215.62
- famrel.x      1      1.338 533.59 215.67
- romantic.y    1      1.404 533.66 215.72
- studytime.x   1      1.465 533.72 215.76
- higher.x      1      1.481 533.74 215.77
- studytime.y   1      1.538 533.79 215.81
- G3.x          1      1.740 534.00 215.96
- paid.x        1      1.942 534.20 216.10
- Medu          1      2.138 534.39 216.24
- famsize       1      2.359 534.62 216.40
- activities.x  1      2.511 534.77 216.51
- G1.x          1      2.530 534.79 216.52
- health.x      1      2.694 534.95 216.64
<none>                       532.26 216.71
- schoolsup.y   1      3.127 535.38 216.95
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- internet       1      3.403 535.66 217.15
- schoolsup.x    1      3.668 535.92 217.33
- traveltime.x   1      3.732 535.99 217.38
- guardian.y     1      3.822 536.08 217.44
- age            1      3.893 536.15 217.49
- famsup.y       1      3.902 536.16 217.50
- Pstatus        1      4.199 536.45 217.71
- guardian.x     1      4.308 536.56 217.79
- famsup.x       1      4.357 536.61 217.82
- failures.x     1      4.527 536.78 217.95
+ famrel.y       1      0.201 532.06 218.57
+ Dalc.y         1      0.169 532.09 218.59
+ goout.y        1      0.165 532.09 218.59
+ Dalc.x         1      0.163 532.09 218.59
+ health.y       1      0.158 532.10 218.60
+ traveltime.y   1      0.158 532.10 218.60
+ paid.y         1      0.133 532.12 218.62
+ freetime.y     1      0.119 532.14 218.63
+ Walc.x         1      0.104 532.15 218.64
- sex            1      5.502 537.76 218.64
+ Walc.y         1      0.089 532.17 218.65
+ freetime.x     1      0.081 532.18 218.65
+ activities.y   1      0.015 532.24 218.70
+ nursery        1      0.007 532.25 218.71
- absences.x     1      7.067 539.32 219.75
- Mjob           4     15.703 547.96 219.82
- G1.y           1      7.425 539.68 220.00
- absences.y     1      7.726 539.98 220.22
+ Fjob           4      6.046 526.21 220.35
- reason         3     14.739 546.99 221.15
- failures.y     1     10.264 542.52 222.01
- school         1     15.111 547.37 225.41
- G2.y           1    236.213 768.47 355.01

Step:  AIC=215.15
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Mjob + reason + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + goout.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + studytime.y + failures.y +
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        schoolsup.y + famsup.y + higher.y + romantic.y + absences.y +
        G1.y + G2.y

                   Df Sum of Sq    RSS    AIC
- higher.y      1      0.719 533.59 213.66
- romantic.x    1      0.932 533.80 213.82
- address       1      0.964 533.83 213.84
- G2.x          1      1.193 534.06 214.00
- romantic.y    1      1.345 534.21 214.11
- famrel.x      1      1.351 534.22 214.12
- goout.x       1      1.380 534.25 214.14
- studytime.x   1      1.427 534.29 214.17
- higher.x      1      1.525 534.39 214.24
- studytime.y   1      1.531 534.40 214.25
- G3.x          1      1.858 534.73 214.48
- paid.x        1      1.895 534.76 214.51
- famsize       1      2.298 535.17 214.79
- G1.x          1      2.302 535.17 214.80
- activities.x  1      2.387 535.25 214.86
<none>                       532.87 215.15
- health.x      1      2.889 535.76 215.21
- schoolsup.y   1      3.045 535.91 215.33
- internet      1      3.308 536.18 215.51
- schoolsup.x   1      3.630 536.50 215.74
- guardian.y    1      3.800 536.67 215.86
- age           1      3.941 536.81 215.96
- famsup.y      1      3.983 536.85 215.99
- Pstatus       1      4.086 536.95 216.07
- traveltime.x  1      4.196 537.06 216.15
- failures.x    1      4.289 537.16 216.21
- guardian.x    1      4.377 537.24 216.27
- famsup.x      1      4.402 537.27 216.29
- Medu          1      4.987 537.85 216.71
+ Fedu          1      0.611 532.26 216.71
- sex           1      5.391 538.26 217.00
+ famrel.y      1      0.188 532.68 217.01
+ Dalc.y        1      0.166 532.70 217.03
+ traveltime.y  1      0.165 532.70 217.03
+ health.y      1      0.165 532.70 217.03
+ paid.y        1      0.162 532.71 217.03
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+ Dalc.x         1     0.161 532.71 217.03
+ goout.y        1     0.149 532.72 217.04
+ freetime.y     1     0.084 532.78 217.09
+ Walc.x         1     0.077 532.79 217.09
+ Walc.y         1     0.064 532.80 217.10
+ freetime.x     1     0.053 532.81 217.11
+ activities.y   1     0.009 532.86 217.14
+ nursery        1     0.002 532.87 217.15
- absences.x     1     6.927 539.79 218.08
- Mjob           4    15.513 548.38 218.11
+ Fjob           4     6.599 526.27 218.39
- absences.y     1     7.594 540.46 218.55
- G1.y           1     7.627 540.49 218.58
- reason         3    14.662 547.53 219.52
- failures.y     1    10.067 542.93 220.30
- school         1    15.317 548.18 223.97
- G2.y           1   235.615 768.48 353.02

Step:  AIC=213.66
G3.y ~ school + sex + age + address + famsize + Pstatus + Medu +
    Mjob + reason + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + goout.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + romantic.y + absences.y + G1.y +
    G2.y

                 Df Sum of Sq    RSS    AIC
- address         1     0.922 534.51 212.32
- romantic.x      1     0.963 534.55 212.35
- studytime.x     1     1.102 534.69 212.45
- goout.x         1     1.130 534.72 212.47
- studytime.y     1     1.195 534.78 212.52
- G2.x            1     1.270 534.86 212.57
- famrel.x        1     1.371 534.96 212.65
- romantic.y      1     1.391 534.98 212.66
- G3.x            1     1.924 535.51 213.04
- paid.x          1     1.966 535.55 213.07
- higher.x        1     2.021 535.61 213.11
- G1.x            1     2.255 535.84 213.28
```

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- activities.x  1      2.293 535.88 213.30
- famsize       1      2.302 535.89 213.31
- health.x      1      2.795 536.38 213.66
<none>                       533.59 213.66
- guardian.y    1      3.283 536.87 214.01
- famsup.y      1      3.401 536.99 214.09
- internet      1      3.482 537.07 214.15
- famsup.x      1      3.884 537.47 214.44
- guardian.x    1      3.976 537.56 214.50
- age           1      3.979 537.57 214.50
- Pstatus       1      4.105 537.69 214.59
- traveltime.x  1      4.260 537.85 214.70
- failures.x    1      4.478 538.06 214.86
+ famrel.y      1      0.843 532.74 215.06
+ health.y      1      0.822 532.76 215.08
+ higher.y      1      0.719 532.87 215.15
+ goout.y       1      0.680 532.91 215.18
+ Fedu          1      0.655 532.93 215.20
+ activities.y  1      0.440 533.15 215.35
- Medu          1      5.362 538.95 215.48
+ Dalc.x        1      0.201 533.39 215.52
+ paid.y        1      0.182 533.40 215.53
+ Dalc.y        1      0.180 533.41 215.54
- sex           1      5.541 539.13 215.61
+ freetime.x    1      0.058 533.53 215.62
+ freetime.y    1      0.054 533.53 215.63
+ Walc.x        1      0.047 533.54 215.63
+ traveltime.y  1      0.016 533.57 215.65
+ Walc.y        1      0.016 533.57 215.65
+ nursery       1      0.005 533.58 215.66
- absences.x    1      6.760 540.35 216.47
- Mjob          4     15.529 549.12 216.62
- absences.y    1      7.251 540.84 216.82
- G1.y          1      7.365 540.95 216.90
+ Fjob          4      6.569 527.02 216.93
- schoolsup.y   1      8.852 542.44 217.95
- reason        3     14.689 548.28 218.04
- failures.y    1      9.512 543.10 218.41
- schoolsup.x   1     10.196 543.78 218.90
- school        1     15.646 549.23 222.71
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- G2.y           1   239.621 773.21 353.36

Step:  AIC=212.32
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + goout.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + romantic.y + absences.y + G1.y +
    G2.y

                Df Sum of Sq     RSS    AIC
- goout.x        1     0.913 535.42 210.98
- romantic.x     1     1.152 535.66 211.15
- G2.x           1     1.157 535.67 211.15
- studytime.x    1     1.160 535.67 211.15
- studytime.y    1     1.234 535.74 211.20
- famrel.x       1     1.373 535.88 211.30
- romantic.y     1     1.640 536.15 211.49
- G3.x           1     1.805 536.31 211.61
- paid.x         1     1.959 536.47 211.72
- higher.x       1     1.990 536.50 211.74
- activities.x   1     2.010 536.52 211.76
- G1.x           1     2.073 536.58 211.80
- famsize        1     2.101 536.61 211.82
<none>                        534.51 212.32
- health.x       1     2.833 537.34 212.34
- famsup.y       1     3.419 537.93 212.76
- guardian.y     1     3.423 537.93 212.76
- traveltime.x   1     3.533 538.04 212.84
- age            1     3.648 538.16 212.92
- famsup.x       1     3.872 538.38 213.08
- guardian.x     1     4.063 538.57 213.22
- internet       1     4.096 538.60 213.24
- Pstatus        1     4.171 538.68 213.29
- failures.x     1     4.665 539.17 213.64
+ address        1     0.922 533.59 213.66
+ Fedu           1     0.761 533.75 213.78
+ famrel.y       1     0.725 533.78 213.81
+ health.y       1     0.724 533.79 213.81
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+ higher.y        1       0.678 533.83 213.84
+ goout.y         1       0.573 533.94 213.91
+ activities.y  1       0.431 534.08 214.02
- Medu            1       5.271 539.78 214.07
+ Dalc.x          1       0.280 534.23 214.12
+ paid.y          1       0.277 534.23 214.13
+ Dalc.y          1       0.255 534.25 214.14
+ freetime.x    1       0.052 534.46 214.29
+ freetime.y    1       0.046 534.46 214.29
+ nursery        1       0.016 534.49 214.31
+ Walc.x          1       0.013 534.50 214.31
+ traveltime.y 1       0.007 534.50 214.32
+ Walc.y          1       0.001 534.51 214.32
- sex             1       5.701 540.21 214.38
- Mjob            4      15.592 550.10 215.31
- absences.x    1       7.097 541.61 215.36
- G1.y            1       7.194 541.70 215.43
- absences.y    1       7.270 541.78 215.49
+ Fjob            4       6.614 527.89 215.57
- schoolsup.y   1       8.573 543.08 216.40
- failures.y    1       9.140 543.65 216.80
- reason          3      15.431 549.94 217.20
- schoolsup.x   1       9.883 544.39 217.32
- school          1      17.733 552.24 222.79
- G2.y            1     247.466 781.98 355.67

Step:  AIC=210.98
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + health.x + absences.x +
    G1.x + G2.x + G3.x + guardian.y + studytime.y + failures.y +
    schoolsup.y + famsup.y + romantic.y + absences.y + G1.y +
    G2.y

               Df Sum of Sq    RSS    AIC
- G2.x            1       0.970 536.39 209.67
- romantic.x    1       1.173 536.59 209.81
- studytime.x   1       1.227 536.65 209.85
- famrel.x       1       1.257 536.68 209.87
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- studytime.y    1      1.303 536.72 209.90
- G3.x           1      1.588 537.01 210.11
- romantic.y     1      1.682 537.10 210.17
- activities.x   1      1.864 537.29 210.30
- higher.x       1      1.887 537.31 210.32
- paid.x         1      2.052 537.47 210.44
- G1.x           1      2.131 537.55 210.49
- famsize        1      2.155 537.58 210.51
- health.x       1      2.645 538.07 210.86
<none>                        535.42 210.98
- age            1      3.138 538.56 211.21
- traveltime.x   1      3.410 538.83 211.40
- guardian.y     1      3.439 538.86 211.42
- famsup.y       1      3.441 538.86 211.42
- internet       1      3.784 539.21 211.67
- famsup.x       1      3.913 539.33 211.76
- guardian.x     1      4.042 539.46 211.85
- Pstatus        1      4.236 539.66 211.99
+ goout.y        1      1.225 534.20 212.10
+ goout.x        1      0.913 534.51 212.32
+ Fedu           1      0.845 534.58 212.37
- failures.x     1      4.888 540.31 212.45
+ address        1      0.705 534.72 212.47
+ Dalc.x         1      0.553 534.87 212.58
+ Dalc.y         1      0.520 534.90 212.60
+ health.y       1      0.490 534.93 212.63
+ famrel.y       1      0.460 534.96 212.65
+ higher.y       1      0.460 534.96 212.65
+ activities.y   1      0.319 535.10 212.75
+ paid.y         1      0.253 535.17 212.80
+ freetime.x     1      0.246 535.18 212.80
+ freetime.y     1      0.231 535.19 212.81
+ Walc.y         1      0.120 535.30 212.89
+ Walc.x         1      0.081 535.34 212.92
+ nursery        1      0.020 535.40 212.96
+ traveltime.y   1      0.005 535.42 212.97
- Medu           1      5.770 541.19 213.07
- sex            1      5.886 541.31 213.15
- G1.y           1      6.864 542.29 213.84
- absences.y     1      6.918 542.34 213.88
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- absences.x     1       6.932 542.35 213.89
- Mjob           4      15.732 551.15 214.04
+ Fjob           4       6.792 528.63 214.10
- schoolsup.y    1       8.166 543.59 214.76
- failures.y     1       9.098 544.52 215.41
- schoolsup.x    1       9.431 544.85 215.65
- reason         3      15.381 550.80 215.80
- school         1      17.243 552.66 221.08
- G2.y           1     252.643 788.06 356.63

Step:  AIC=209.67
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + health.x + absences.x +
    G1.x + G3.x + guardian.y + studytime.y + failures.y + schoolsup.y +
    famsup.y + romantic.y + absences.y + G1.y + G2.y

                Df Sum of Sq     RSS     AIC
- G3.x           1       0.658 537.05 208.14
- studytime.x    1       1.183 537.57 208.51
- romantic.x     1       1.210 537.60 208.53
- studytime.y    1       1.250 537.64 208.56
- G1.x           1       1.277 537.67 208.58
- activities.x   1       1.636 538.03 208.83
- romantic.y     1       1.770 538.16 208.93
- famrel.x       1       1.799 538.19 208.95
- higher.x       1       2.064 538.46 209.13
- famsize        1       2.274 538.67 209.28
- paid.x         1       2.291 538.68 209.30
- health.x       1       2.446 538.84 209.41
<none>                         536.39 209.67
- famsup.y       1       3.231 539.62 209.96
- age            1       3.256 539.65 209.98
- guardian.y     1       3.498 539.89 210.15
- internet       1       3.538 539.93 210.18
- famsup.x       1       3.711 540.10 210.30
- traveltime.x   1       3.866 540.26 210.41
- guardian.x     1       4.170 540.56 210.63
- Pstatus        1       4.207 540.60 210.65
```

```
+ goout.y        1      1.038 535.35 210.93
+ G2.x           1      0.970 535.42 210.98
- failures.x     1      4.754 541.15 211.04
+ Fedu           1      0.824 535.57 211.08
+ goout.x        1      0.726 535.67 211.15
+ address        1      0.634 535.76 211.22
+ health.y       1      0.617 535.77 211.23
+ Dalc.x         1      0.604 535.79 211.24
+ famrel.y       1      0.566 535.83 211.26
+ Dalc.y         1      0.565 535.83 211.27
+ higher.y       1      0.535 535.86 211.29
+ activities.y   1      0.380 536.01 211.40
+ paid.y         1      0.288 536.10 211.46
+ freetime.x     1      0.186 536.21 211.53
+ freetime.y     1      0.176 536.22 211.54
+ Walc.y         1      0.119 536.27 211.58
+ Walc.x         1      0.075 536.32 211.61
+ traveltime.y   1      0.015 536.38 211.66
+ nursery        1      0.012 536.38 211.66
- Medu           1      5.827 542.22 211.79
- sex            1      5.847 542.24 211.81
- absences.x     1      6.541 542.93 212.30
- absences.y     1      6.881 543.27 212.54
+ Fjob           4      6.974 529.42 212.67
- G1.y           1      7.265 543.66 212.81
- Mjob           4     16.126 552.52 212.98
- schoolsup.y    1      8.313 544.70 213.54
- failures.y     1      9.303 545.70 214.24
- schoolsup.x    1      9.550 545.94 214.41
- reason         3     15.552 551.94 214.59
- school         1     17.176 553.57 219.71
- G2.y           1    251.817 788.21 354.70

Step:  AIC=208.14
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + studytime.x +
    failures.x + schoolsup.x + famsup.x + paid.x + activities.x +
    higher.x + romantic.x + famrel.x + health.x + absences.x +
    G1.x + guardian.y + studytime.y + failures.y + schoolsup.y +
    famsup.y + romantic.y + absences.y + G1.y + G2.y
```

```
                  Df Sum of Sq     RSS     AIC
- studytime.x      1     1.019  538.07  206.86
- studytime.y      1     1.070  538.12  206.90
- romantic.x       1     1.238  538.29  207.02
- activities.x     1     1.478  538.53  207.19
- romantic.y       1     1.741  538.79  207.37
- famrel.x         1     1.939  538.99  207.51
- higher.x         1     2.035  539.08  207.58
- paid.x           1     2.103  539.15  207.63
- famsize          1     2.132  539.18  207.65
- health.x         1     2.350  539.40  207.80
<none>                          537.05  208.14
- age              1     2.830  539.88  208.14
- famsup.y         1     2.901  539.95  208.19
- guardian.y       1     3.347  540.40  208.51
- famsup.x         1     3.365  540.41  208.52
- internet         1     3.694  540.74  208.75
- traveltime.x     1     3.720  540.77  208.77
- guardian.x       1     4.015  541.06  208.98
- Pstatus          1     4.256  541.31  209.15
+ goout.y          1     0.994  536.06  209.43
+ Fedu             1     0.931  536.12  209.47
- G1.x             1     4.853  541.90  209.57
+ health.y         1     0.732  536.32  209.61
+ goout.x          1     0.677  536.37  209.65
+ G3.x             1     0.658  536.39  209.67
+ famrel.y         1     0.631  536.42  209.69
+ address          1     0.623  536.43  209.69
- failures.x       1     5.036  542.09  209.70
+ higher.y         1     0.543  536.51  209.75
+ Dalc.x           1     0.536  536.51  209.75
+ Dalc.y           1     0.495  536.55  209.78
+ activities.y     1     0.418  536.63  209.84
+ paid.y           1     0.274  536.78  209.94
- sex              1     5.468  542.52  210.01
+ freetime.x       1     0.167  536.88  210.02
+ freetime.y       1     0.164  536.89  210.02
+ Walc.y           1     0.072  536.98  210.08
+ traveltime.y     1     0.049  537.00  210.10
```

```
+ G2.x           1      0.040 537.01 210.11
+ Walc.x         1      0.035 537.01 210.11
+ nursery        1      0.003 537.05 210.13
- Medu           1      5.803 542.85 210.24
- absences.x     1      5.936 542.99 210.33
- absences.y     1      6.402 543.45 210.66
- Mjob           4     15.640 552.69 211.10
- G1.y           1      7.050 544.10 211.12
+ Fjob           4      6.977 530.07 211.14
- schoolsup.y    1      7.746 544.80 211.61
- failures.y     1      8.900 545.95 212.41
- schoolsup.x    1      8.928 545.98 212.43
- reason         3     14.988 552.04 212.65
- school         1     16.866 553.92 217.95
- G2.y           1    265.121 802.17 359.41

Step:  AIC=206.86
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + failures.x +
    schoolsup.x + famsup.x + paid.x + activities.x + higher.x +
    romantic.x + famrel.x + health.x + absences.x + G1.x + guardian.y +
    studytime.y + failures.y + schoolsup.y + famsup.y + romantic.y +
    absences.y + G1.y + G2.y

                Df Sum of Sq    RSS    AIC
- studytime.y    1      0.072 538.14 204.91
- romantic.x     1      0.540 538.61 205.24
- romantic.y     1      0.929 539.00 205.52
- activities.x   1      1.433 539.50 205.88
- famrel.x       1      1.839 539.91 206.16
- famsup.y       1      1.898 539.97 206.21
- higher.x       1      1.996 540.06 206.27
- health.x       1      2.101 540.17 206.35
- famsize        1      2.214 540.28 206.43
- famsup.x       1      2.410 540.48 206.57
- paid.x         1      2.426 540.49 206.58
- age            1      2.764 540.83 206.82
<none>                        538.07 206.86
- guardian.y     1      3.207 541.28 207.13
- traveltime.x   1      3.783 541.85 207.54
```

```
- internet        1       3.828 541.90 207.57
- guardian.x      1       3.891 541.96 207.61
+ health.y        1       1.703 536.37 207.65
- Pstatus         1       4.227 542.30 207.85
+ activities.y    1       1.387 536.68 207.87
- G1.x            1       4.327 542.40 207.92
+ studytime.x     1       1.019 537.05 208.14
+ Fedu            1       0.870 537.20 208.24
+ goout.y         1       0.853 537.22 208.25
+ goout.x         1       0.739 537.33 208.34
+ address         1       0.664 537.40 208.39
+ Dalc.x          1       0.509 537.56 208.50
+ G3.x            1       0.494 537.57 208.51
+ Dalc.y          1       0.494 537.57 208.51
+ famrel.y        1       0.383 537.69 208.59
+ paid.y          1       0.380 537.69 208.59
- sex             1       5.291 543.36 208.60
+ higher.y        1       0.270 537.80 208.67
+ freetime.x      1       0.192 537.88 208.72
- failures.x      1       5.478 543.55 208.73
+ freetime.y      1       0.113 537.96 208.78
+ G2.x            1       0.064 538.01 208.82
+ Walc.y          1       0.059 538.01 208.82
+ Walc.x          1       0.055 538.01 208.82
+ traveltime.y    1       0.026 538.04 208.84
+ nursery         1       0.014 538.06 208.85
- Medu            1       5.677 543.75 208.87
- absences.x      1       5.777 543.85 208.94
- absences.y      1       5.872 543.94 209.01
- schoolsup.y     1       6.738 544.81 209.61
- Mjob            4      15.543 553.61 209.74
+ Fjob            4       6.968 531.10 209.88
- G1.y            1       7.651 545.72 210.25
- schoolsup.x     1       7.909 545.98 210.43
- failures.y      1       8.235 546.30 210.66
- reason          3      15.192 553.26 211.50
- school          1      16.499 554.57 216.40
- G2.y            1     264.869 802.94 357.77

Step:  AIC=204.91
```

```
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + failures.x +
    schoolsup.x + famsup.x + paid.x + activities.x + higher.x +
    romantic.x + famrel.x + health.x + absences.x + G1.x + guardian.y +
    failures.y + schoolsup.y + famsup.y + romantic.y + absences.y +
    G1.y + G2.y

                 Df Sum of Sq    RSS    AIC
- romantic.x    1      0.535 538.68 203.29
- romantic.y    1      0.926 539.07 203.57
- activities.x  1      1.495 539.64 203.97
- famrel.x      1      1.846 539.99 204.22
- famsup.y      1      1.869 540.01 204.24
- higher.x      1      2.028 540.17 204.35
- health.x      1      2.086 540.23 204.39
- famsize       1      2.253 540.39 204.51
- famsup.x      1      2.385 540.53 204.60
- paid.x        1      2.388 540.53 204.60
<none>                        538.14 204.91
- age           1      2.863 541.00 204.94
- guardian.y    1      3.225 541.37 205.19
- traveltime.x  1      3.741 541.88 205.56
- internet      1      3.893 542.03 205.66
- guardian.x    1      3.907 542.05 205.68
+ health.y      1      1.724 536.42 205.69
- Pstatus       1      4.199 542.34 205.88
+ activities.y  1      1.423 536.72 205.90
- G1.x          1      4.408 542.55 206.03
+ Fedu          1      0.920 537.22 206.26
+ goout.y       1      0.850 537.29 206.31
+ goout.x       1      0.743 537.40 206.38
+ address       1      0.626 537.51 206.47
+ Dalc.x        1      0.526 537.61 206.54
+ Dalc.y        1      0.512 537.63 206.55
+ G3.x          1      0.463 537.68 206.58
+ famrel.y      1      0.373 537.77 206.65
+ paid.y        1      0.370 537.77 206.65
+ higher.y      1      0.267 537.87 206.72
+ freetime.x    1      0.211 537.93 206.76
+ freetime.y    1      0.127 538.01 206.82
```

```
- failures.x      1       5.547 543.69 206.83
+ Walc.y          1       0.074 538.07 206.86
+ studytime.y     1       0.072 538.07 206.86
+ Walc.x          1       0.071 538.07 206.86
+ G2.x            1       0.067 538.07 206.86
+ traveltime.y    1       0.030 538.11 206.89
+ studytime.x     1       0.021 538.12 206.90
+ nursery         1       0.019 538.12 206.90
- Medu            1       5.654 543.79 206.90
- absences.y      1       5.800 543.94 207.01
- sex             1       5.815 543.96 207.02
- absences.x      1       5.840 543.98 207.03
- schoolsup.y     1       6.706 544.85 207.64
- Mjob            4      15.476 553.62 207.74
+ Fjob            4       6.995 531.15 207.91
- G1.y            1       7.710 545.85 208.35
- schoolsup.x     1       7.867 546.01 208.46
- failures.y      1       8.352 546.49 208.79
- reason          3      15.356 553.50 209.66
- school          1      16.708 554.85 214.59
- G2.y            1     265.003 803.14 355.87

Step:  AIC=203.29
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + failures.x +
    schoolsup.x + famsup.x + paid.x + activities.x + higher.x +
    famrel.x + health.x + absences.x + G1.x + guardian.y + failures.y +
    schoolsup.y + famsup.y + romantic.y + absences.y + G1.y +
    G2.y

              Df Sum of Sq    RSS    AIC
- romantic.y    1       1.511 540.19 202.36
- famsup.y      1       1.515 540.19 202.36
- activities.x  1       1.614 540.29 202.43
- famrel.x      1       1.755 540.43 202.53
- famsup.x      1       1.995 540.67 202.70
- health.x      1       2.012 540.69 202.72
- higher.x      1       2.146 540.82 202.81
- famsize       1       2.316 540.99 202.93
- paid.x        1       2.336 541.01 202.94
```

```
<none>                        538.68 203.29
- age            1     2.852 541.53 203.31
- guardian.y     1     2.911 541.59 203.35
+ health.y       1     2.089 536.59 203.81
- guardian.x     1     3.737 542.41 203.93
- traveltime.x   1     3.765 542.44 203.95
- internet       1     3.770 542.45 203.95
- Pstatus        1     4.198 542.87 204.26
- G1.x           1     4.493 543.17 204.46
+ goout.y        1     0.912 537.76 204.64
+ Fedu           1     0.902 537.77 204.65
+ goout.x        1     0.730 537.95 204.77
+ address        1     0.726 537.95 204.78
+ Dalc.x         1     0.607 538.07 204.86
+ romantic.x     1     0.535 538.14 204.91
+ G3.x           1     0.533 538.14 204.91
+ Dalc.y         1     0.502 538.17 204.93
+ activities.y   1     0.446 538.23 204.97
+ higher.y       1     0.360 538.32 205.04
+ paid.y         1     0.290 538.39 205.09
+ freetime.x     1     0.238 538.44 205.12
+ freetime.y     1     0.120 538.56 205.21
+ famrel.y       1     0.100 538.58 205.22
+ Walc.y         1     0.078 538.60 205.24
+ Walc.x         1     0.074 538.60 205.24
+ studytime.y    1     0.066 538.61 205.24
+ G2.x           1     0.058 538.62 205.25
+ studytime.x    1     0.032 538.64 205.27
- absences.y     1     5.641 544.32 205.27
+ nursery        1     0.025 538.65 205.27
+ traveltime.y   1     0.010 538.67 205.28
- absences.x     1     5.684 544.36 205.30
- failures.x     1     5.693 544.37 205.31
- Medu           1     5.820 544.50 205.40
- sex            1     6.209 544.88 205.67
- schoolsup.y    1     6.580 545.26 205.93
- Mjob           4    15.617 554.29 206.21
+ Fjob           4     6.997 531.68 206.30
- G1.y           1     7.530 546.21 206.59
- schoolsup.x    1     7.762 546.44 206.76
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- failures.y   1     8.008 546.68 206.93
- reason       3    15.522 554.20 208.14
- school       1    16.569 555.25 212.86
- G2.y         1   264.835 803.51 354.04

Step:  AIC=202.36
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + failures.x +
    schoolsup.x + famsup.x + paid.x + activities.x + higher.x +
    famrel.x + health.x + absences.x + G1.x + guardian.y + failures.y +
    schoolsup.y + famsup.y + absences.y + G1.y + G2.y

                 Df Sum of Sq    RSS    AIC
- famsup.y       1     1.480 541.67 201.41
- famrel.x       1     1.530 541.72 201.44
- health.x       1     1.735 541.92 201.59
- higher.x       1     1.778 541.96 201.62
- famsup.x       1     1.980 542.17 201.76
- activities.x   1     1.995 542.18 201.77
- famsize        1     2.149 542.34 201.88
- paid.x         1     2.311 542.50 201.99
- guardian.y     1     2.619 542.81 202.21
<none>                       540.19 202.36
- age            1     3.293 543.48 202.68
- guardian.x     1     3.414 543.60 202.77
+ health.y       1     2.119 538.07 202.86
- traveltime.x   1     3.688 543.87 202.96
+ romantic.y     1     1.511 538.68 203.29
- internet       1     4.216 544.40 203.33
- Pstatus        1     4.477 544.66 203.51
+ romantic.x     1     1.120 539.07 203.57
+ goout.y        1     1.013 539.17 203.64
- G1.x           1     4.731 544.92 203.69
+ Fedu           1     0.883 539.30 203.74
+ address        1     0.815 539.37 203.78
+ goout.x        1     0.801 539.39 203.79
+ Dalc.x         1     0.603 539.58 203.93
+ Dalc.y         1     0.478 539.71 204.02
+ higher.y       1     0.419 539.77 204.06
- Medu           1     5.319 545.51 204.10
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155

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- absences.x      1      5.327 545.51 204.11
+ activities.y    1      0.327 539.86 204.13
- absences.y      1      5.394 545.58 204.16
+ G3.x            1      0.286 539.90 204.16
+ paid.y          1      0.279 539.91 204.16
+ freetime.x      1      0.206 539.98 204.22
+ G2.x            1      0.201 539.99 204.22
- failures.x      1      5.518 545.70 204.24
+ Walc.y          1      0.098 540.09 204.29
+ studytime.y     1      0.092 540.09 204.30
+ Walc.x          1      0.092 540.09 204.30
+ freetime.y      1      0.091 540.10 204.30
+ famrel.y        1      0.071 540.12 204.31
+ studytime.x     1      0.057 540.13 204.32
+ nursery         1      0.046 540.14 204.33
+ traveltime.y    1      0.012 540.17 204.35
- Mjob            4     14.752 554.94 204.65
- schoolsup.y     1      6.888 547.07 205.20
- sex             1      7.032 547.22 205.30
+ Fjob            4      7.042 533.14 205.35
- G1.y            1      7.791 547.98 205.83
- schoolsup.x     1      8.260 548.45 206.16
- failures.y      1      8.601 548.79 206.39
- reason          3     15.004 555.19 206.83
- school          1     16.181 556.37 211.63
- G2.y            1    263.328 803.51 352.05

Step:  AIC=201.41
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + failures.x +
    schoolsup.x + famsup.x + paid.x + activities.x + higher.x +
    famrel.x + health.x + absences.x + G1.x + guardian.y + failures.y +
    schoolsup.y + absences.y + G1.y + G2.y

              Df Sum of Sq    RSS     AIC
- guardian.y   1      1.144 542.81 200.21
- famrel.x     1      1.383 543.05 200.38
- famsup.x     1      1.400 543.07 200.39
- higher.x     1      1.435 543.10 200.42
- health.x     1      1.762 543.43 200.65
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- activities.x   1      1.803 543.47 200.67
- guardian.x     1      1.964 543.63 200.79
- famsize        1      2.056 543.72 200.85
- paid.x         1      2.462 544.13 201.14
<none>                        541.67 201.41
- age            1      3.207 544.87 201.66
+ health.y       1      2.461 539.20 201.67
- traveltime.x   1      3.700 545.37 202.01
- internet       1      4.196 545.86 202.35
+ famsup.y       1      1.480 540.19 202.36
+ romantic.y     1      1.475 540.19 202.36
- G1.x           1      4.456 546.12 202.54
+ activities.y   1      1.225 540.44 202.54
+ romantic.x     1      1.212 540.45 202.55
- Pstatus        1      4.494 546.16 202.56
+ Fedu           1      0.936 540.73 202.74
+ goout.y        1      0.827 540.84 202.82
+ goout.x        1      0.785 540.88 202.85
+ address        1      0.752 540.91 202.88
+ Dalc.y         1      0.490 541.18 203.06
- absences.y     1      5.213 546.88 203.06
+ Dalc.x         1      0.463 541.20 203.08
- absences.x     1      5.270 546.94 203.10
+ paid.y         1      0.236 541.43 203.24
+ G2.x           1      0.218 541.45 203.25
+ traveltime.y   1      0.178 541.49 203.28
+ freetime.x     1      0.172 541.49 203.28
+ G3.x           1      0.165 541.50 203.29
- Medu           1      5.544 547.21 203.30
+ Walc.x         1      0.113 541.55 203.33
- failures.x     1      5.602 547.27 203.34
+ studytime.x    1      0.088 541.58 203.34
+ freetime.y     1      0.069 541.60 203.36
+ Walc.y         1      0.069 541.60 203.36
+ studytime.y    1      0.063 541.60 203.36
+ higher.y       1      0.060 541.61 203.36
+ nursery        1      0.038 541.63 203.38
+ famrel.y       1      0.015 541.65 203.39
- Mjob           4     14.809 556.48 203.71
- schoolsup.y    1      6.918 548.58 204.25
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- sex              1      7.073 548.74 204.36
+ Fjob             4      7.093 534.57 204.37
- G1.y             1      7.600 549.27 204.73
- schoolsup.x      1      8.291 549.96 205.21
- failures.y       1      8.582 550.25 205.41
- reason           3     14.914 556.58 205.78
- school           1     16.008 557.67 210.53
- G2.y             1    267.376 809.04 352.66
```

Step: AIC=200.21
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + failures.x +
    schoolsup.x + famsup.x + paid.x + activities.x + higher.x +
    famrel.x + health.x + absences.x + G1.x + failures.y + schoolsup.y +
    absences.y + G1.y + G2.y

```
                 Df Sum of Sq     RSS    AIC
- famsup.x        1      1.097 543.91 198.98
- higher.x        1      1.134 543.94 199.01
- guardian.x      2      3.991 546.80 199.01
- famrel.x        1      1.184 543.99 199.04
- activities.x    1      1.671 544.48 199.39
- health.x        1      1.690 544.50 199.40
- famsize         1      2.153 544.96 199.72
- paid.x          1      2.165 544.97 199.73
<none>                         542.81 200.21
- age             1      2.961 545.77 200.29
+ activities.y    1      2.045 540.76 200.77
- G1.x            1      3.760 546.57 200.85
+ health.y        1      1.741 541.07 200.98
- traveltime.x    1      3.979 546.79 201.00
- internet        1      4.214 547.02 201.17
+ romantic.x      1      1.402 541.41 201.22
- Pstatus         1      4.395 547.20 201.29
+ romantic.y      1      1.223 541.59 201.35
+ guardian.y      1      1.144 541.67 201.41
- absences.y      1      4.874 547.68 201.63
+ goout.x         1      0.827 541.98 201.63
- absences.x      1      4.884 547.69 201.63
+ goout.y         1      0.812 542.00 201.64
```

```
+ Fedu          1     0.794 542.02 201.65
+ famrel.y      1     0.771 542.04 201.67
+ address       1     0.737 542.07 201.69
+ higher.y      1     0.524 542.29 201.84
+ Dalc.y        1     0.479 542.33 201.87
+ Dalc.x        1     0.458 542.35 201.89
+ G2.x          1     0.298 542.51 202.00
- Medu          1     5.437 548.25 202.02
+ paid.y        1     0.233 542.58 202.05
+ freetime.x    1     0.185 542.63 202.08
+ G3.x          1     0.128 542.68 202.12
+ studytime.y   1     0.119 542.69 202.13
+ Walc.y        1     0.114 542.70 202.13
+ Walc.x        1     0.110 542.70 202.13
+ studytime.x   1     0.050 542.76 202.18
+ nursery       1     0.043 542.77 202.18
+ freetime.y    1     0.021 542.79 202.20
+ traveltime.y  1     0.008 542.80 202.21
+ famsup.y      1     0.005 542.81 202.21
- failures.x    1     6.109 548.92 202.49
- Mjob          4    14.921 557.73 202.57
- sex           1     6.730 549.54 202.92
- schoolsup.y   1     6.922 549.73 203.05
+ Fjob          4     7.098 535.71 203.18
- failures.y    1     8.251 551.06 203.97
- G1.y          1     8.254 551.06 203.98
- schoolsup.x   1     8.283 551.09 204.00
- reason        3    15.145 557.96 204.72
- school        1    15.782 558.59 209.16
- G2.y          1   268.904 811.71 351.92

Step:  AIC=198.98
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + guardian.x + traveltime.x + failures.x +
    schoolsup.x + paid.x + activities.x + higher.x + famrel.x +
    health.x + absences.x + G1.x + failures.y + schoolsup.y +
    absences.y + G1.y + G2.y

              Df Sum of Sq    RSS    AIC
- guardian.x   2     4.004 547.91 197.78
```

```
- higher.x      1      1.150 545.06 197.79
- famrel.x      1      1.196 545.10 197.82
- health.x      1      1.467 545.37 198.01
- activities.x  1      1.528 545.44 198.05
- paid.x        1      1.573 545.48 198.09
- famsize       1      2.411 546.32 198.67
- age           1      2.733 546.64 198.90
<none>                 543.91 198.98
- G1.x          1      3.303 547.21 199.30
+ activities.y  1      1.887 542.02 199.65
+ health.y      1      1.709 542.20 199.78
+ romantic.x    1      1.492 542.42 199.93
- traveltime.x  1      4.256 548.16 199.96
- internet      1      4.354 548.26 200.03
+ romantic.y    1      1.349 542.56 200.03
- Pstatus       1      4.373 548.28 200.04
+ famsup.x      1      1.097 542.81 200.21
+ famsup.y      1      0.990 542.92 200.29
+ goout.x       1      0.876 543.03 200.37
+ goout.y       1      0.862 543.04 200.38
+ guardian.y    1      0.841 543.07 200.39
- Medu          1      5.005 548.91 200.48
+ Fedu          1      0.628 543.28 200.54
+ famrel.y      1      0.627 543.28 200.54
- absences.x    1      5.108 549.02 200.55
+ address       1      0.601 543.31 200.56
+ higher.y      1      0.546 543.36 200.60
- absences.y    1      5.227 549.13 200.64
+ Dalc.y        1      0.485 543.42 200.64
+ Dalc.x        1      0.449 543.46 200.67
+ G2.x          1      0.326 543.58 200.75
+ Walc.x        1      0.174 543.73 200.86
+ Walc.y        1      0.166 543.74 200.87
+ studytime.y   1      0.164 543.74 200.87
+ paid.y        1      0.146 543.76 200.88
+ G3.x          1      0.129 543.78 200.89
+ freetime.x    1      0.128 543.78 200.89
+ studytime.x   1      0.103 543.80 200.91
+ nursery       1      0.055 543.85 200.94
+ freetime.y    1      0.012 543.90 200.97
```

```
+ traveltime.y  1      0.004 543.90 200.98
- failures.x    1      6.250 550.16 201.35
+ Fjob          4      7.292 536.62 201.83
- schoolsup.y   1      7.050 550.96 201.90
- Mjob          4     15.912 559.82 202.00
- sex           1      7.394 551.30 202.14
- failures.y    1      7.875 551.78 202.47
- schoolsup.x   1      8.341 552.25 202.80
- G1.y          1      8.536 552.44 202.93
- reason        3     15.910 559.82 204.00
- school        1     16.633 560.54 208.49
- G2.y          1    269.218 813.13 350.59

Step:  AIC=197.78
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
    paid.x + activities.x + higher.x + famrel.x + health.x +
    absences.x + G1.x + failures.y + schoolsup.y + absences.y +
    G1.y + G2.y

               Df Sum of Sq     RSS     AIC
- paid.x        1      1.308 549.22 196.70
- famrel.x      1      1.325 549.24 196.71
- higher.x      1      1.362 549.27 196.73
- activities.x  1      1.569 549.48 196.88
- health.x      1      1.570 549.48 196.88
- famsize       1      2.576 550.49 197.58
<none>                        547.91 197.78
- G1.x          1      2.951 550.86 197.84
+ activities.y  1      2.143 545.77 198.29
- age           1      3.837 551.75 198.45
+ romantic.x    1      1.657 546.25 198.63
+ health.y      1      1.586 546.33 198.68
+ romantic.y    1      1.408 546.50 198.80
- internet      1      4.604 552.52 198.98
+ guardian.x    2      4.004 543.91 198.98
- traveltime.x  1      4.615 552.53 198.99
+ famsup.x      1      1.111 546.80 199.01
+ famsup.y      1      1.092 546.82 199.02
+ famrel.y      1      0.908 547.00 199.15
```

```
+ Fedu          1      0.899 547.01 199.16
- Medu          1      4.917 552.83 199.20
+ goout.x       1      0.812 547.10 199.22
+ goout.y       1      0.767 547.14 199.25
+ higher.y      1      0.765 547.15 199.25
+ address       1      0.556 547.36 199.40
+ Dalc.y        1      0.539 547.37 199.41
- absences.x    1      5.247 553.16 199.43
+ Dalc.x        1      0.496 547.42 199.44
+ guardian.y    2      3.315 544.60 199.47
+ G2.x          1      0.405 547.51 199.50
- absences.y    1      5.440 553.35 199.56
+ Walc.x        1      0.277 547.63 199.59
+ Walc.y        1      0.277 547.63 199.59
+ studytime.y   1      0.193 547.72 199.65
- Pstatus       1      5.613 553.52 199.68
+ G3.x          1      0.137 547.77 199.69
+ studytime.x   1      0.100 547.81 199.72
+ paid.y        1      0.090 547.82 199.72
+ freetime.x    1      0.046 547.87 199.75
+ traveltime.y  1      0.028 547.88 199.77
+ nursery       1      0.005 547.91 199.78
+ freetime.y    1      0.003 547.91 199.78
- failures.x    1      6.043 553.95 199.97
+ Fjob          4      7.734 540.18 200.35
- schoolsup.y   1      6.763 554.67 200.47
- failures.y    1      6.990 554.90 200.63
- Mjob          4     16.150 564.06 200.88
- sex           1      7.898 555.81 201.25
- schoolsup.x   1      8.187 556.10 201.45
- G1.y          1      8.331 556.24 201.55
- reason        3     16.029 563.94 202.80
- school        1     18.048 565.96 208.16
- G2.y          1    270.150 818.06 348.90

Step:  AIC=196.7
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
    activities.x + higher.x + famrel.x + health.x + absences.x +
    G1.x + failures.y + schoolsup.y + absences.y + G1.y + G2.y
```

```
                Df Sum of Sq    RSS     AIC
- higher.x       1     1.105 550.32 195.46
- famrel.x       1     1.404 550.62 195.67
- health.x       1     1.483 550.70 195.73
- activities.x   1     1.785 551.00 195.93
- famsize        1     2.639 551.86 196.53
<none>                         549.22 196.70
- G1.x           1     3.226 552.44 196.93
+ activities.y   1     2.360 546.86 197.05
- age            1     3.727 552.95 197.28
+ health.y       1     1.878 547.34 197.39
- internet       1     4.040 553.26 197.49
+ romantic.x     1     1.600 547.62 197.58
+ romantic.y     1     1.379 547.84 197.73
+ paid.x         1     1.308 547.91 197.78
- traveltime.x   1     4.584 553.80 197.87
+ guardian.x     2     3.739 545.48 198.09
+ goout.x        1     0.874 548.34 198.09
+ Fedu           1     0.853 548.37 198.10
+ goout.y        1     0.820 548.40 198.12
+ famrel.y       1     0.757 548.46 198.17
+ Dalc.y         1     0.754 548.46 198.17
- Medu           1     5.070 554.29 198.21
+ Dalc.x         1     0.693 548.53 198.21
+ higher.y       1     0.688 548.53 198.22
+ address        1     0.591 548.63 198.28
+ famsup.x       1     0.563 548.66 198.30
+ G2.x           1     0.563 548.66 198.30
+ famsup.y       1     0.512 548.71 198.34
+ Walc.x         1     0.460 548.76 198.37
+ Walc.y         1     0.440 548.78 198.39
+ guardian.y     2     3.158 546.06 198.49
- failures.x     1     5.524 554.74 198.52
+ paid.y         1     0.179 549.04 198.57
- absences.x     1     5.603 554.82 198.57
+ studytime.y    1     0.119 549.10 198.61
+ G3.x           1     0.068 549.15 198.65
+ studytime.x    1     0.049 549.17 198.66
+ freetime.x     1     0.030 549.19 198.67
```

```
+ freetime.y     1      0.009 549.21 198.69
+ traveltime.y  1      0.005 549.21 198.69
+ nursery       1      0.000 549.22 198.70
- Pstatus       1      6.098 555.32 198.91
- absences.y    1      6.458 555.68 199.16
- Mjob          4     15.308 564.53 199.20
+ Fjob          4      7.577 541.64 199.39
- schoolsup.y   1      6.810 556.03 199.40
- failures.y    1      6.863 556.08 199.44
- sex           1      7.303 556.52 199.74
- schoolsup.x   1      8.160 557.38 200.33
- G1.y          1      8.337 557.56 200.45
- reason        3     16.560 565.78 202.04
- school        1     17.761 566.98 206.85
- G2.y          1    270.465 819.68 347.66

Step:  AIC=195.46
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
    activities.x + famrel.x + health.x + absences.x + G1.x +
    failures.y + schoolsup.y + absences.y + G1.y + G2.y

                Df Sum of Sq    RSS    AIC
- health.x       1      1.494 551.82 194.50
- famrel.x       1      1.508 551.83 194.51
- activities.x   1      2.151 552.48 194.95
- famsize        1      2.688 553.01 195.32
<none>                        550.32 195.46
- age            1      3.132 553.46 195.63
- G1.x           1      3.370 553.69 195.80
+ health.y       1      2.090 548.23 196.01
+ activities.y   1      2.019 548.30 196.06
- internet       1      3.769 554.09 196.07
+ higher.y       1      1.712 548.61 196.27
+ romantic.x     1      1.235 549.09 196.60
+ romantic.y     1      1.135 549.19 196.67
+ higher.x       1      1.105 549.22 196.70
+ guardian.x     2      3.954 546.37 196.71
+ paid.x         1      1.051 549.27 196.73
- traveltime.x   1      4.740 555.06 196.74
```

164

```
- Medu            1      4.941 555.26 196.88
+ Fedu            1      0.794 549.53 196.91
+ goout.y         1      0.786 549.54 196.92
+ goout.x         1      0.774 549.55 196.93
+ famsup.x        1      0.626 549.70 197.03
+ Dalc.y          1      0.594 549.73 197.05
+ address         1      0.583 549.74 197.06
+ G2.x            1      0.576 549.75 197.06
+ Dalc.x          1      0.573 549.75 197.07
+ guardian.y      2      3.443 546.88 197.07
+ famsup.y        1      0.569 549.76 197.07
+ famrel.y        1      0.470 549.85 197.14
+ Walc.x          1      0.360 549.96 197.21
+ Walc.y          1      0.353 549.97 197.22
- absences.x      1      5.474 555.80 197.24
+ paid.y          1      0.159 550.16 197.35
+ studytime.y     1      0.149 550.18 197.36
+ G3.x            1      0.089 550.23 197.40
+ studytime.x     1      0.077 550.25 197.41
+ freetime.x      1      0.019 550.31 197.45
+ freetime.y      1      0.018 550.31 197.45
+ nursery         1      0.001 550.32 197.46
+ traveltime.y    1      0.000 550.32 197.46
- Pstatus         1      6.169 556.49 197.72
- absences.y      1      6.184 556.51 197.73
- Mjob            4     15.304 565.63 197.94
+ Fjob            4      7.787 542.54 198.02
- failures.x      1      6.841 557.16 198.18
- failures.y      1      7.143 557.47 198.39
- schoolsup.y     1      7.897 558.22 198.91
- G1.y            1      8.206 558.53 199.12
- sex             1      8.316 558.64 199.19
- schoolsup.x     1      9.392 559.72 199.93
- reason          3     17.541 567.87 201.45
- school          1     17.105 567.43 205.16
- G2.y            1    274.497 824.82 348.04

Step:  AIC=194.5
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
```

165

```
        activities.x + famrel.x + absences.x + G1.x + failures.y +
        schoolsup.y + absences.y + G1.y + G2.y

                Df Sum of Sq     RSS     AIC
- famrel.x       1     1.223  553.04  193.34
- activities.x   1     2.022  553.84  193.90
- famsize        1     2.449  554.27  194.19
<none>                        551.82  194.50
- G1.x           1     3.323  555.14  194.79
- age            1     3.373  555.19  194.83
+ health.y       1     2.132  549.69  195.02
+ activities.y   1     1.862  549.96  195.21
+ higher.y       1     1.734  550.08  195.30
+ health.x       1     1.494  550.32  195.46
- internet       1     4.491  556.31  195.59
- Medu           1     4.516  556.33  195.61
+ guardian.x     2     4.049  547.77  195.69
+ higher.x       1     1.116  550.70  195.73
- traveltime.x   1     4.772  556.59  195.79
+ romantic.x     1     1.015  550.80  195.80
+ Fedu           1     0.980  550.84  195.82
+ paid.x         1     0.972  550.85  195.82
+ romantic.y     1     0.906  550.91  195.87
+ Dalc.y         1     0.675  551.14  196.03
+ Dalc.x         1     0.646  551.17  196.05
+ goout.y        1     0.645  551.17  196.05
+ guardian.y     2     3.512  548.31  196.06
+ goout.x        1     0.629  551.19  196.06
+ address        1     0.614  551.20  196.07
+ G2.x           1     0.492  551.33  196.16
+ famsup.x       1     0.473  551.34  196.17
+ famrel.y       1     0.454  551.36  196.18
+ famsup.y       1     0.421  551.40  196.21
+ Walc.x         1     0.413  551.41  196.21
+ Walc.y         1     0.410  551.41  196.21
- absences.x     1     5.581  557.40  196.34
+ paid.y         1     0.196  551.62  196.36
+ studytime.y    1     0.122  551.70  196.41
+ G3.x           1     0.079  551.74  196.44
+ studytime.x    1     0.063  551.76  196.46
```

```
+ freetime.x     1       0.021 551.80 196.48
+ freetime.y     1       0.012 551.81 196.49
+ traveltime.y   1       0.000 551.82 196.50
+ nursery        1       0.000 551.82 196.50
- Mjob           4      14.657 566.48 196.51
- absences.y     1       6.168 557.99 196.74
+ Fjob           4       8.109 543.71 196.84
- Pstatus        1       6.327 558.14 196.85
- failures.x     1       6.928 558.75 197.26
- failures.y     1       7.135 558.95 197.41
- schoolsup.y    1       7.715 559.53 197.80
- G1.y           1       8.048 559.87 198.03
- sex            1       8.782 560.60 198.53
- schoolsup.x    1       9.081 560.90 198.73
- reason         3      17.269 569.09 200.27
- school         1      16.581 568.40 203.81
- G2.y           1     280.899 832.72 349.68

Step:  AIC=193.34
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
    activities.x + absences.x + G1.x + failures.y + schoolsup.y +
    absences.y + G1.y + G2.y

                Df Sum of Sq    RSS    AIC
- activities.x  1       2.164 555.20 192.84
- famsize       1       2.486 555.53 193.06
<none>                        553.04 193.34
- G1.x          1       3.357 556.40 193.66
- age           1       3.719 556.76 193.90
+ health.y      1       1.811 551.23 194.09
+ higher.y      1       1.726 551.31 194.15
+ activities.y  1       1.674 551.37 194.19
+ famrel.y      1       1.527 551.51 194.29
- Medu          1       4.415 557.46 194.38
+ guardian.x    2       4.167 548.87 194.45
+ famrel.x      1       1.223 551.82 194.50
+ higher.x      1       1.210 551.83 194.51
+ health.x      1       1.208 551.83 194.51
+ paid.x        1       1.034 552.01 194.63
```

```
- traveltime.x   1      4.801 557.84 194.65
+ Fedu           1      0.993 552.05 194.66
- internet       1      4.881 557.92 194.70
+ Dalc.y         1      0.888 552.15 194.73
+ romantic.x     1      0.866 552.17 194.75
+ Dalc.x         1      0.843 552.20 194.76
+ guardian.y     2      3.677 549.36 194.80
+ romantic.y     1      0.782 552.26 194.80
+ G2.x           1      0.650 552.39 194.90
+ Walc.x         1      0.614 552.43 194.92
+ Walc.y         1      0.609 552.43 194.92
+ address        1      0.595 552.45 194.93
+ goout.y        1      0.582 552.46 194.94
+ goout.x        1      0.498 552.54 195.00
+ famsup.x       1      0.485 552.56 195.01
- Mjob           4     14.217 567.26 195.04
+ famsup.y       1      0.424 552.62 195.05
+ G3.x           1      0.135 552.91 195.25
+ studytime.y    1      0.127 552.91 195.26
+ paid.y         1      0.127 552.91 195.26
+ studytime.x    1      0.071 552.97 195.30
+ freetime.y     1      0.060 552.98 195.30
+ traveltime.y   1      0.001 553.04 195.34
+ freetime.x     1      0.001 553.04 195.34
+ nursery        1      0.000 553.04 195.34
- absences.x     1      5.877 558.92 195.38
- absences.y     1      6.019 559.06 195.48
- Pstatus        1      6.101 559.14 195.54
+ Fjob           4      7.898 545.14 195.85
- failures.y     1      7.222 560.26 196.30
- failures.x     1      7.302 560.34 196.35
- G1.y           1      7.675 560.72 196.61
- schoolsup.y    1      7.746 560.79 196.66
- sex            1      8.491 561.53 197.16
- schoolsup.x    1      9.109 562.15 197.58
- reason         3     17.218 570.26 199.06
- school         1     17.899 570.94 203.51
- G2.y           1    283.283 836.32 349.33

Step:  AIC=192.84
```

```
G3.y ~ school + sex + age + famsize + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
    absences.x + G1.x + failures.y + schoolsup.y + absences.y +
    G1.y + G2.y

                 Df Sum of Sq    RSS    AIC
- famsize         1     2.632 557.84 192.64
<none>                         555.20 192.84
+ activities.y    1     2.877 552.33 192.85
- G1.x            1     3.222 558.43 193.05
- age             1     3.555 558.76 193.27
+ activities.x    1     2.164 553.04 193.34
+ higher.y        1     2.049 553.16 193.42
+ famrel.y        1     1.667 553.54 193.69
+ health.y        1     1.634 553.57 193.71
+ higher.x        1     1.597 553.61 193.74
- Medu            1     4.264 559.47 193.76
+ famrel.x        1     1.365 553.84 193.90
+ guardian.x      2     4.238 550.97 193.91
+ paid.x          1     1.218 553.99 194.00
+ Dalc.y          1     1.086 554.12 194.09
+ health.x        1     1.075 554.13 194.10
+ Dalc.x          1     1.072 554.13 194.10
+ romantic.x      1     1.063 554.14 194.10
+ romantic.y      1     1.055 554.15 194.11
+ guardian.y      2     3.810 551.39 194.21
+ Fedu            1     0.813 554.39 194.28
- traveltime.x    1     5.039 560.24 194.29
- internet        1     5.087 560.29 194.32
+ Walc.x          1     0.735 554.47 194.33
+ Walc.y          1     0.719 554.49 194.34
+ G2.x            1     0.676 554.53 194.37
+ goout.y         1     0.482 554.72 194.50
- absences.x      1     5.423 560.63 194.55
- Pstatus         1     5.429 560.63 194.55
+ address         1     0.408 554.80 194.56
+ goout.x         1     0.401 554.80 194.56
+ famsup.x        1     0.366 554.84 194.58
+ famsup.y        1     0.315 554.89 194.62
+ studytime.y     1     0.225 554.98 194.68
```

169

```
- absences.y     1      5.656 560.86 194.71
+ studytime.x    1      0.157 555.05 194.73
+ freetime.y     1      0.118 555.09 194.75
+ G3.x           1      0.055 555.15 194.80
+ paid.y         1      0.045 555.16 194.80
+ freetime.x     1      0.015 555.19 194.83
+ traveltime.y   1      0.002 555.20 194.83
+ nursery        1      0.000 555.20 194.84
+ Fjob           4      8.415 546.79 195.00
- Mjob           4     15.194 570.40 195.15
- schoolsup.y    1      7.055 562.26 195.66
- failures.y     1      7.127 562.33 195.71
- failures.x     1      7.345 562.55 195.86
- G1.y           1      7.546 562.75 195.99
- sex            1      7.578 562.78 196.01
- schoolsup.x    1      8.255 563.46 196.47
- reason         3     17.151 572.36 198.46
- school         1     18.654 573.86 203.46
- G2.y           1    287.407 842.61 350.19


Step:  AIC=192.64
G3.y ~ school + sex + age + Pstatus + Medu + Mjob + reason +
    internet + traveltime.x + failures.x + schoolsup.x + absences.x +
    G1.x + failures.y + schoolsup.y + absences.y + G1.y + G2.y

               Df Sum of Sq    RSS    AIC
+ activities.y  1      3.046 554.79 192.55
<none>                       557.84 192.64
- G1.x          1      3.023 560.86 192.71
+ famsize       1      2.632 555.20 192.84
- age           1      3.353 561.19 192.93
- Medu          1      3.484 561.32 193.02
+ activities.x  1      2.310 555.53 193.06
+ higher.y      1      2.123 555.71 193.19
+ famrel.y      1      1.726 556.11 193.46
+ higher.x      1      1.670 556.17 193.50
- Pstatus       1      4.338 562.17 193.60
+ guardian.x    2      4.416 553.42 193.61
+ famrel.x      1      1.410 556.43 193.68
+ Dalc.y        1      1.386 556.45 193.69
```

```
+ health.y        1        1.378 556.46 193.70
+ Dalc.x          1        1.374 556.46 193.70
+ paid.x          1        1.288 556.55 193.76
- traveltime.x    1        4.625 562.46 193.80
+ guardian.y      2        3.983 553.85 193.91
- internet        1        4.878 562.71 193.97
+ Walc.x          1        0.946 556.89 193.99
+ romantic.y      1        0.934 556.90 194.00
+ romantic.x      1        0.930 556.91 194.01
+ Walc.y          1        0.920 556.92 194.01
+ G2.x            1        0.878 556.96 194.04
+ health.x        1        0.862 556.97 194.05
- Mjob            4       14.058 571.89 194.15
+ Fedu            1        0.672 557.16 194.18
+ goout.y         1        0.542 557.29 194.27
+ famsup.x        1        0.530 557.31 194.28
+ famsup.y        1        0.484 557.35 194.31
+ goout.x         1        0.451 557.39 194.33
+ studytime.y     1        0.314 557.52 194.43
+ address         1        0.247 557.59 194.47
+ studytime.x     1        0.223 557.61 194.49
+ freetime.y      1        0.101 557.74 194.57
- absences.y      1        5.789 563.63 194.59
+ paid.y          1        0.040 557.80 194.61
+ nursery         1        0.035 557.80 194.62
+ G3.x            1        0.020 557.82 194.63
+ freetime.x      1        0.008 557.83 194.64
+ traveltime.y    1        0.004 557.83 194.64
- absences.x      1        5.921 563.76 194.68
- schoolsup.y     1        6.737 564.57 195.23
- failures.y      1        6.793 564.63 195.27
- G1.y            1        6.800 564.64 195.27
+ Fjob            4        7.441 550.40 195.51
- failures.x      1        7.304 565.14 195.61
- schoolsup.x     1        7.976 565.81 196.07
- sex             1        8.574 566.41 196.47
- reason          3       16.932 574.77 198.06
- school          1       19.199 577.04 203.57
- G2.y            1      291.148 848.98 351.07
```

```
Step:  AIC=192.55
G3.y ~ school + sex + age + Pstatus + Medu + Mjob + reason +
    internet + traveltime.x + failures.x + schoolsup.x + absences.x +
    G1.x + failures.y + schoolsup.y + absences.y + G1.y + G2.y +
    activities.y

                 Df Sum of Sq     RSS     AIC
<none>                         554.79 192.55
- activities.y  1      3.046 557.84 192.64
+ famsize       1      2.463 552.33 192.85
- G1.x          1      3.433 558.22 192.91
- age           1      3.585 558.38 193.01
- Medu          1      3.655 558.45 193.06
+ higher.y      1      1.667 553.12 193.40
- Mjob          4     13.054 567.84 193.44
+ famrel.y      1      1.549 553.24 193.48
+ health.y      1      1.547 553.24 193.48
- traveltime.x  1      4.328 559.12 193.52
+ guardian.x    2      4.280 550.51 193.59
+ famrel.x      1      1.287 553.50 193.66
+ higher.x      1      1.282 553.51 193.67
- internet      1      4.611 559.40 193.71
+ Dalc.y        1      1.109 553.68 193.79
+ Dalc.x        1      1.102 553.69 193.79
+ health.x      1      1.035 553.76 193.84
+ paid.x        1      1.016 553.77 193.85
+ guardian.y    2      3.858 550.93 193.89
+ activities.x  1      0.956 553.83 193.89
+ Fedu          1      0.867 553.92 193.95
+ G2.x          1      0.789 554.00 194.01
+ Walc.y        1      0.753 554.04 194.03
+ Walc.x        1      0.749 554.04 194.03
+ famsup.x      1      0.731 554.06 194.05
+ goout.y       1      0.729 554.06 194.05
- Pstatus       1      5.110 559.90 194.05
+ romantic.y    1      0.688 554.10 194.08
+ famsup.y      1      0.676 554.11 194.09
+ romantic.x    1      0.674 554.12 194.09
+ goout.x       1      0.561 554.23 194.16
+ address       1      0.448 554.34 194.24
```

```
+ studytime.y   1     0.163 554.63 194.44
+ G3.x          1     0.123 554.67 194.47
+ studytime.x   1     0.117 554.67 194.47
+ paid.y        1     0.106 554.68 194.48
+ freetime.y    1     0.028 554.76 194.53
+ nursery       1     0.027 554.76 194.53
+ traveltime.y  1     0.010 554.78 194.54
+ freetime.x    1     0.000 554.79 194.55
- absences.y    1     6.380 561.17 194.92
- absences.x    1     6.543 561.33 195.03
- schoolsup.y   1     6.613 561.40 195.08
- G1.y          1     6.810 561.60 195.21
- failures.y    1     7.117 561.91 195.42
- failures.x    1     7.135 561.93 195.43
+ Fjob          4     6.893 547.90 195.77
- schoolsup.x   1     7.983 562.77 196.01
- sex           1     9.879 564.67 197.29
- reason        3    17.009 571.80 198.09
- school        1    18.401 573.19 203.02
- G2.y          1   285.332 840.12 349.06

Call:
lm(formula = G3.y ~ school + sex + age + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
    absences.x + G1.x + failures.y + schoolsup.y + absences.y +
    G1.y + G2.y + activities.y, data = data)

Coefficients:
    (Intercept)          schoolMS              sexM               age
       -0.87412          -0.83115          -0.37189           0.09974
        PstatusT              Medu        Mjobhealth          Mjobother
       -0.40567          -0.12478           0.18039          -0.29048
    Mjobservices        Mjobteacher         reasonhome       reasonother
        0.09746           0.26072           0.15733          -0.67047
 reasonreputation       internetyes       traveltime.x        failures.x
       -0.03474           0.32879           0.16532          -0.24495
   schoolsup.xyes        absences.x              G1.x          failures.y
       -1.70934          -0.02110           0.04075          -0.34366
   schoolsup.yyes        absences.y              G1.y              G2.y
        1.59120           0.03221           0.12161           0.84698
```

```
activities.yyes
        0.18731
```

Assim, utilizaremos a seguinte fórmula:

```
modreg_trein_AIC_y <- lm(formula = G3.y ~ school + sex + age + Pstatus + Medu + Mjob +
    reason + internet + traveltime.x + failures.x + schoolsup.x +
    absences.x + G1.x + failures.y + schoolsup.y + absences.y +
    G1.y + G2.y + activities.y, data = data)
```

3. Teste de Shapiro Finalmente, aplicar o teste de **shapiro** nos resíduos

```
shapiro.test(modreg_trein_AIC_x$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC_x$residuals
W = 0.80768, p-value < 2.2e-16
```

```
shapiro.test(modreg_trein_AIC_y$residuals)
```

```
Shapiro-Wilk normality test

data:  modreg_trein_AIC_y$residuals
W = 0.82087, p-value < 2.2e-16
```

Para ambas análises, p-value ¡ 2.2e-16 ¡=¿ p-value muito menor que 0.05 =¿ rejeitamos H0, em que, H0: resíduo distribuido normalmente.

Portanto, o resíduo não é distribuido normalmente.