**Exercicio3.R**

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**library**(data.table)  
base <- **fread**(input = **paste0**("selecao.csv"), header = T, na.strings = "NA", data.table = FALSE, dec=",")  
**names**(base)

## [1] "x1" "x2" "x3" "x4" "x5" "x6" "x7" "x8" "x9" "y"

*# seleção de variaveis modelo 1*  
m0 = **lm**(y **~** 1, data = base)  
m1 = **step**(m0,**list**(lower = **~** 1,  
 upper = **~** x1**+**x2**+**x3**+**x4**+**x5**+**x6**+**x7**+**x8**+**x9),  
 direction = "forward")

## Start: AIC=5655.48  
## y ~ 1  
##   
## Df Sum of Sq RSS AIC  
## + x7 1 53916 21387 3863.8  
## + x9 1 53030 22274 3921.7  
## + x8 1 42439 32865 4476.0  
## + x5 1 33450 41854 4820.5  
## + x6 1 33024 42279 4834.9  
## + x4 1 17408 57896 5282.9  
## + x2 1 257 75047 5652.6  
## + x3 1 253 75050 5652.7  
## <none> 75304 5655.5  
## + x1 1 32 75272 5656.9  
##   
## Step: AIC=3863.78  
## y ~ x7  
##   
## Df Sum of Sq RSS AIC  
## + x9 1 1283.44 20104 3777.6  
## + x8 1 1260.79 20126 3779.2  
## + x6 1 783.20 20604 3812.6  
## + x5 1 420.78 20966 3837.5  
## + x1 1 89.07 21298 3859.8  
## + x4 1 53.18 21334 3862.2  
## <none> 21387 3863.8  
## + x3 1 8.26 21379 3865.2  
## + x2 1 3.51 21384 3865.6  
##   
## Step: AIC=3777.6  
## y ~ x7 + x9  
##   
## Df Sum of Sq RSS AIC  
## + x6 1 123.072 19981 3770.8  
## + x4 1 81.652 20022 3773.8  
## + x1 1 54.956 20049 3775.7  
## + x8 1 36.266 20068 3777.0  
## <none> 20104 3777.6  
## + x5 1 4.217 20100 3779.3  
## + x2 1 0.713 20103 3779.5  
## + x3 1 0.536 20103 3779.6  
##   
## Step: AIC=3770.85  
## y ~ x7 + x9 + x6  
##   
## Df Sum of Sq RSS AIC  
## + x4 1 1080.45 18900 3693.6  
## + x1 1 81.08 19900 3767.1  
## + x8 1 36.90 19944 3770.2  
## + x5 1 34.74 19946 3770.4  
## <none> 19981 3770.8  
## + x2 1 0.78 19980 3772.8  
## + x3 1 0.23 19981 3772.8  
##   
## Step: AIC=3693.63  
## y ~ x7 + x9 + x6 + x4  
##   
## Df Sum of Sq RSS AIC  
## + x5 1 236.064 18664 3677.7  
## + x1 1 62.304 18838 3690.9  
## + x8 1 36.381 18864 3692.9  
## <none> 18900 3693.6  
## + x3 1 1.815 18898 3695.5  
## + x2 1 1.213 18899 3695.5  
##   
## Step: AIC=3677.72  
## y ~ x7 + x9 + x6 + x4 + x5  
##   
## Df Sum of Sq RSS AIC  
## + x1 1 52.902 18611 3675.7  
## + x8 1 40.046 18624 3676.7  
## <none> 18664 3677.7  
## + x3 1 6.807 18657 3679.2  
## + x2 1 1.911 18662 3679.6  
##   
## Step: AIC=3675.67  
## y ~ x7 + x9 + x6 + x4 + x5 + x1  
##   
## Df Sum of Sq RSS AIC  
## + x8 1 41.362 18570 3674.5  
## <none> 18611 3675.7  
## + x3 1 7.054 18604 3677.1  
## + x2 1 3.030 18608 3677.4  
##   
## Step: AIC=3674.5  
## y ~ x7 + x9 + x6 + x4 + x5 + x1 + x8  
##   
## Df Sum of Sq RSS AIC  
## <none> 18570 3674.5  
## + x3 1 6.5176 18563 3676.0  
## + x2 1 3.3522 18567 3676.2

*# Qualidade do Ajuste (análise de resíduos)*  
**plot**(**fitted**(m1), **rstandard**(m1))  
**abline**(0, 0)



**anova**(m1)

## Analysis of Variance Table  
##   
## Response: y  
## Df Sum Sq Mean Sq F value Pr(>F)   
## x7 1 53916 53916 4114.1621 < 2.2e-16 \*\*\*  
## x9 1 1283 1283 97.9346 < 2.2e-16 \*\*\*  
## x6 1 123 123 9.3911 0.002222 \*\*   
## x4 1 1080 1080 82.4448 < 2.2e-16 \*\*\*  
## x5 1 236 236 18.0132 2.336e-05 \*\*\*  
## x1 1 53 53 4.0368 0.044708 \*   
## x8 1 41 41 3.1562 0.075854 .   
## Residuals 1417 18570 13   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

**summary**(m1)

##   
## Call:  
## lm(formula = y ~ x7 + x9 + x6 + x4 + x5 + x1 + x8, data = base)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -46.172 -1.925 0.169 2.063 16.032   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -6.5374685 1.4415446 -4.535 6.24e-06 \*\*\*  
## x7 -0.2638935 0.4659336 -0.566 0.5712   
## x9 0.9462288 0.4643885 2.038 0.0418 \*   
## x6 0.2664206 0.0278735 9.558 < 2e-16 \*\*\*  
## x4 -0.2068910 0.0211328 -9.790 < 2e-16 \*\*\*  
## x5 0.3019813 0.0720512 4.191 2.95e-05 \*\*\*  
## x1 -0.0011609 0.0005707 -2.034 0.0421 \*   
## x8 -0.8250781 0.4644232 -1.777 0.0759 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 3.62 on 1417 degrees of freedom  
## Multiple R-squared: 0.7534, Adjusted R-squared: 0.7522   
## F-statistic: 618.4 on 7 and 1417 DF, p-value: < 2.2e-16

**anova**(m1)

## Analysis of Variance Table  
##   
## Response: y  
## Df Sum Sq Mean Sq F value Pr(>F)   
## x7 1 53916 53916 4114.1621 < 2.2e-16 \*\*\*  
## x9 1 1283 1283 97.9346 < 2.2e-16 \*\*\*  
## x6 1 123 123 9.3911 0.002222 \*\*   
## x4 1 1080 1080 82.4448 < 2.2e-16 \*\*\*  
## x5 1 236 236 18.0132 2.336e-05 \*\*\*  
## x1 1 53 53 4.0368 0.044708 \*   
## x8 1 41 41 3.1562 0.075854 .   
## Residuals 1417 18570 13   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

*# transformação das variáveis*  
base**$**x1sqrt = base**$**x1 **^** 2  
base**$**x2sqrt = base**$**x2 **^** 2  
base**$**x3sqrt = base**$**x3 **^** 2  
base**$**x4sqrt = base**$**x4 **^** 2  
base**$**x5sqrt = base**$**x5 **^** 2  
base**$**x6sqrt = base**$**x6 **^** 2  
base**$**x7sqrt = base**$**x7 **^** 2  
base**$**x8sqrt = base**$**x8 **^** 2  
base**$**x9sqrt = base**$**x9 **^** 2  
  
*# seleção de variaveis modelo 2*  
m0 = **lm**(y **~** 1, data = base)  
m2 = **step**(m0, **list**(lower = **~** 1,  
 upper = **~** x1 **+** x2 **+** x3 **+** x4 **+** x5 **+** x6 **+** x7 **+** x8 **+** x9 **+**  
 x1sqrt **+** x2sqrt **+** x3sqrt **+** x4sqrt **+** x5sqrt **+** x6sqrt **+** x7sqrt **+** x8sqrt **+** x9sqrt),  
 direction = "forward")

## Start: AIC=5655.48  
## y ~ 1  
##   
## Df Sum of Sq RSS AIC  
## + x7 1 53916 21387 3863.8  
## + x9 1 53030 22274 3921.7  
## + x8 1 42439 32865 4476.0  
## + x7sqrt 1 36918 38385 4697.2  
## + x5 1 33450 41854 4820.5  
## + x6 1 33024 42279 4834.9  
## + x6sqrt 1 31826 43477 4874.8  
## + x9sqrt 1 30948 44356 4903.2  
## + x5sqrt 1 29295 46008 4955.4  
## + x8sqrt 1 21855 53449 5169.0  
## + x4 1 17408 57896 5282.9  
## + x4sqrt 1 14964 60339 5341.8  
## + x2 1 257 75047 5652.6  
## + x3 1 253 75050 5652.7  
## + x3sqrt 1 251 75052 5652.7  
## + x2sqrt 1 193 75110 5653.8  
## <none> 75304 5655.5  
## + x1 1 32 75272 5656.9  
## + x1sqrt 1 4 75299 5657.4  
##   
## Step: AIC=3863.78  
## y ~ x7  
##   
## Df Sum of Sq RSS AIC  
## + x7sqrt 1 12083.5 9303.7 2679.6  
## + x9sqrt 1 2311.6 19075.6 3702.8  
## + x9 1 1283.4 20103.8 3777.6  
## + x8 1 1260.8 20126.4 3779.2  
## + x6 1 783.2 20604.0 3812.6  
## + x8sqrt 1 487.6 20899.6 3832.9  
## + x6sqrt 1 445.6 20941.6 3835.8  
## + x5 1 420.8 20966.4 3837.5  
## + x1 1 89.1 21298.1 3859.8  
## + x4 1 53.2 21334.0 3862.2  
## + x1sqrt 1 49.4 21337.8 3862.5  
## + x5sqrt 1 43.4 21343.8 3862.9  
## <none> 21387.2 3863.8  
## + x3 1 8.3 21378.9 3865.2  
## + x4sqrt 1 8.0 21379.2 3865.3  
## + x3sqrt 1 3.8 21383.4 3865.5  
## + x2 1 3.5 21383.7 3865.6  
## + x2sqrt 1 1.6 21385.6 3865.7  
##   
## Step: AIC=2679.65  
## y ~ x7 + x7sqrt  
##   
## Df Sum of Sq RSS AIC  
## + x9 1 3712.2 5591.5 1956.1  
## + x8 1 3693.3 5610.4 1960.9  
## + x9sqrt 1 1150.4 8153.3 2493.6  
## + x8sqrt 1 1100.6 8203.1 2502.2  
## + x5 1 632.8 8670.9 2581.3  
## + x6 1 615.1 8688.7 2584.2  
## + x6sqrt 1 600.9 8702.8 2586.5  
## + x5sqrt 1 486.0 8817.7 2605.2  
## + x4 1 170.2 9133.6 2655.3  
## + x4sqrt 1 132.4 9171.3 2661.2  
## + x1 1 116.0 9187.7 2663.8  
## + x1sqrt 1 95.9 9207.8 2666.9  
## + x2 1 42.4 9261.4 2675.1  
## + x2sqrt 1 31.0 9272.7 2676.9  
## <none> 9303.7 2679.7  
## + x3 1 11.7 9292.0 2679.8  
## + x3sqrt 1 9.0 9294.7 2680.3  
##   
## Step: AIC=1956.1  
## y ~ x7 + x7sqrt + x9  
##   
## Df Sum of Sq RSS AIC  
## + x9sqrt 1 3533.6 2057.9 533.73  
## + x8sqrt 1 3248.6 2343.0 718.57  
## + x4sqrt 1 355.4 5236.2 1864.53  
## + x4 1 213.6 5378.0 1902.60  
## + x5sqrt 1 161.1 5430.4 1916.43  
## + x6sqrt 1 160.6 5430.9 1916.56  
## + x6 1 85.1 5506.5 1936.25  
## + x5 1 67.6 5523.9 1940.76  
## + x1 1 54.7 5536.8 1944.08  
## + x1sqrt 1 40.4 5551.2 1947.77  
## + x2 1 27.9 5563.7 1950.97  
## + x2sqrt 1 20.9 5570.7 1952.77  
## <none> 5591.5 1956.10  
## + x8 1 3.3 5588.2 1957.25  
## + x3sqrt 1 0.2 5591.4 1958.05  
## + x3 1 0.1 5591.5 1958.08  
##   
## Step: AIC=533.73  
## y ~ x7 + x7sqrt + x9 + x9sqrt  
##   
## Df Sum of Sq RSS AIC  
## + x4 1 610.76 1447.2 34.00  
## + x4sqrt 1 505.00 1552.9 134.51  
## + x6 1 429.49 1628.4 202.17  
## + x6sqrt 1 406.51 1651.4 222.13  
## + x5 1 287.42 1770.5 321.36  
## + x5sqrt 1 219.01 1838.9 375.39  
## + x1 1 52.55 2005.4 498.87  
## + x1sqrt 1 40.86 2017.1 507.15  
## + x2 1 18.68 2039.2 522.73  
## + x2sqrt 1 14.59 2043.3 525.59  
## + x3 1 6.34 2051.6 531.33  
## + x3sqrt 1 6.21 2051.7 531.42  
## <none> 2057.9 533.73  
## + x8 1 2.02 2055.9 534.33  
## + x8sqrt 1 0.17 2057.8 535.61  
##   
## Step: AIC=34  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4  
##   
## Df Sum of Sq RSS AIC  
## + x4sqrt 1 25.6879 1421.5 10.474  
## + x2 1 18.6014 1428.6 17.561  
## + x5sqrt 1 16.0948 1431.1 20.059  
## + x1 1 15.7760 1431.4 20.376  
## + x2sqrt 1 15.5009 1431.7 20.650  
## + x1sqrt 1 14.1643 1433.0 21.980  
## + x5 1 5.3505 1441.8 30.718  
## + x8sqrt 1 4.1251 1443.0 31.928  
## + x8 1 3.2531 1443.9 32.789  
## <none> 1447.2 33.996  
## + x6sqrt 1 0.6553 1446.5 35.350  
## + x3sqrt 1 0.2214 1447.0 35.778  
## + x3 1 0.1260 1447.0 35.872  
## + x6 1 0.0988 1447.1 35.899  
##   
## Step: AIC=10.47  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt  
##   
## Df Sum of Sq RSS AIC  
## + x2 1 16.8783 1404.6 -4.5471  
## + x2sqrt 1 13.9478 1407.5 -1.5771  
## + x1 1 10.9125 1410.6 1.4925  
## + x1sqrt 1 10.7150 1410.8 1.6920  
## + x5sqrt 1 6.8710 1414.6 5.5695  
## + x8sqrt 1 6.4964 1415.0 5.9468  
## + x8 1 3.5362 1417.9 8.9249  
## + x5 1 3.1005 1418.4 9.3627  
## <none> 1421.5 10.4743  
## + x6 1 0.4193 1421.1 12.0539  
## + x6sqrt 1 0.3498 1421.1 12.1236  
## + x3sqrt 1 0.1937 1421.3 12.2801  
## + x3 1 0.1701 1421.3 12.3038  
##   
## Step: AIC=-4.55  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt + x2  
##   
## Df Sum of Sq RSS AIC  
## + x5sqrt 1 7.0259 1397.6 -9.6929  
## + x8sqrt 1 6.1363 1398.5 -8.7862  
## + x8 1 3.6481 1401.0 -6.2530  
## + x5 1 3.4024 1401.2 -6.0031  
## + x1 1 3.2011 1401.4 -5.7984  
## + x1sqrt 1 3.1173 1401.5 -5.7132  
## <none> 1404.6 -4.5471  
## + x2sqrt 1 1.0229 1403.6 -3.5852  
## + x3sqrt 1 0.3934 1404.2 -2.9462  
## + x6 1 0.3806 1404.2 -2.9332  
## + x3 1 0.3631 1404.2 -2.9155  
## + x6sqrt 1 0.3112 1404.3 -2.8629  
##   
## Step: AIC=-9.69  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt + x2 + x5sqrt  
##   
## Df Sum of Sq RSS AIC  
## + x5 1 9.5645 1388.0 -17.4787  
## + x8sqrt 1 5.0152 1392.6 -12.8158  
## + x8 1 3.4570 1394.1 -11.2221  
## + x1sqrt 1 2.9101 1394.7 -10.6633  
## + x1 1 2.8592 1394.7 -10.6112  
## <none> 1397.6 -9.6929  
## + x2sqrt 1 0.8220 1396.8 -8.5313  
## + x6 1 0.7443 1396.8 -8.4521  
## + x3 1 0.6349 1396.9 -8.3405  
## + x3sqrt 1 0.6094 1397.0 -8.3144  
## + x6sqrt 1 0.5502 1397.0 -8.2541  
##   
## Step: AIC=-17.48  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt + x2 + x5sqrt + x5  
##   
## Df Sum of Sq RSS AIC  
## + x8sqrt 1 5.7644 1382.2 -21.409  
## + x8 1 3.7916 1384.2 -19.377  
## + x1sqrt 1 3.0453 1385.0 -18.609  
## + x1 1 2.9664 1385.0 -18.527  
## <none> 1388.0 -17.479  
## + x6 1 1.6185 1386.4 -17.141  
## + x6sqrt 1 1.1214 1386.9 -16.630  
## + x2sqrt 1 0.7897 1387.2 -16.290  
## + x3 1 0.3904 1387.6 -15.880  
## + x3sqrt 1 0.3625 1387.7 -15.851  
##   
## Step: AIC=-21.41  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt + x2 + x5sqrt + x5 +   
## x8sqrt  
##   
## Df Sum of Sq RSS AIC  
## + x8 1 4.8636 1377.4 -24.432  
## + x1sqrt 1 2.7895 1379.5 -22.288  
## + x1 1 2.6732 1379.6 -22.168  
## <none> 1382.2 -21.409  
## + x6 1 1.1017 1381.1 -20.545  
## + x6sqrt 1 0.7646 1381.5 -20.198  
## + x2sqrt 1 0.6816 1381.6 -20.112  
## + x3 1 0.4716 1381.8 -19.895  
## + x3sqrt 1 0.4469 1381.8 -19.870  
##   
## Step: AIC=-24.43  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt + x2 + x5sqrt + x5 +   
## x8sqrt + x8  
##   
## Df Sum of Sq RSS AIC  
## + x1sqrt 1 2.61471 1374.8 -25.140  
## + x1 1 2.48650 1374.9 -25.007  
## <none> 1377.4 -24.432  
## + x6 1 1.00737 1376.4 -23.474  
## + x2sqrt 1 0.72949 1376.7 -23.187  
## + x6sqrt 1 0.68601 1376.7 -23.142  
## + x3 1 0.52423 1376.9 -22.974  
## + x3sqrt 1 0.49806 1376.9 -22.947  
##   
## Step: AIC=-25.14  
## y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt + x2 + x5sqrt + x5 +   
## x8sqrt + x8 + x1sqrt  
##   
## Df Sum of Sq RSS AIC  
## <none> 1374.8 -25.140  
## + x6 1 1.10736 1373.7 -24.288  
## + x6sqrt 1 0.76060 1374.0 -23.928  
## + x3 1 0.50175 1374.3 -23.660  
## + x2sqrt 1 0.45557 1374.3 -23.612  
## + x3sqrt 1 0.44316 1374.3 -23.599  
## + x1 1 0.08695 1374.7 -23.230

*# Qualidade do Ajuste (análise de resíduos)*  
**plot**(**fitted**(m2), **rstandard**(m2))  
**abline**(0, 0)



**anova**(m2)

## Analysis of Variance Table  
##   
## Response: y  
## Df Sum Sq Mean Sq F value Pr(>F)   
## x7 1 53916 53916 55376.6783 < 2.2e-16 \*\*\*  
## x7sqrt 1 12083 12083 12410.7327 < 2.2e-16 \*\*\*  
## x9 1 3712 3712 3812.7111 < 2.2e-16 \*\*\*  
## x9sqrt 1 3534 3534 3629.3205 < 2.2e-16 \*\*\*  
## x4 1 611 611 627.3036 < 2.2e-16 \*\*\*  
## x4sqrt 1 26 26 26.3836 3.190e-07 \*\*\*  
## x2 1 17 17 17.3354 3.323e-05 \*\*\*  
## x5sqrt 1 7 7 7.2162 0.007310 \*\*   
## x5 1 10 10 9.8235 0.001758 \*\*   
## x8sqrt 1 6 6 5.9205 0.015089 \*   
## x8 1 5 5 4.9953 0.025571 \*   
## x1sqrt 1 3 3 2.6855 0.101487   
## Residuals 1412 1375 1   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

**summary**(m2)

##   
## Call:  
## lm(formula = y ~ x7 + x7sqrt + x9 + x9sqrt + x4 + x4sqrt + x2 +   
## x5sqrt + x5 + x8sqrt + x8 + x1sqrt, data = base)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2.88560 -0.80695 0.00462 0.83966 2.98555   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 1.942e-01 6.658e-01 0.292 0.770622   
## x7 3.753e-01 1.312e-01 2.860 0.004293 \*\*   
## x7sqrt -5.654e-03 1.510e-03 -3.743 0.000189 \*\*\*  
## x9 1.144e+00 1.275e-01 8.967 < 2e-16 \*\*\*  
## x9sqrt -1.080e-02 6.363e-04 -16.974 < 2e-16 \*\*\*  
## x4 -8.615e-02 1.356e-02 -6.355 2.8e-10 \*\*\*  
## x4sqrt 1.726e-04 1.374e-04 1.256 0.209294   
## x2 -1.883e-01 6.370e-02 -2.956 0.003163 \*\*   
## x5sqrt 7.326e-03 1.922e-03 3.811 0.000144 \*\*\*  
## x5 -2.805e-01 8.386e-02 -3.344 0.000846 \*\*\*  
## x8sqrt -3.122e-03 1.204e-03 -2.593 0.009619 \*\*   
## x8 2.801e-01 1.276e-01 2.194 0.028363 \*   
## x1sqrt -4.242e-07 2.588e-07 -1.639 0.101487   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.9867 on 1412 degrees of freedom  
## Multiple R-squared: 0.9817, Adjusted R-squared: 0.9816   
## F-statistic: 6328 on 12 and 1412 DF, p-value: < 2.2e-16

*# Modelo Final*  
m3 = **lm**(y **~** x2 **+** x4 **+** x5 **+** x7 **+** x8 **+** x9 **+** x5sqrt **+** x7sqrt **+** x8sqrt **+** x9sqrt, data = base)  
  
*# Qualidade do Ajuste (análise de resíduos)*  
**plot**(**fitted**(m3), **rstandard**(m3))  
**abline**(0, 0)



**anova**(m3)

## Analysis of Variance Table  
##   
## Response: y  
## Df Sum Sq Mean Sq F value Pr(>F)   
## x2 1 256.8 256.8 263.323 < 2.2e-16 \*\*\*  
## x4 1 17256.2 17256.2 17691.116 < 2.2e-16 \*\*\*  
## x5 1 18399.7 18399.7 18863.472 < 2.2e-16 \*\*\*  
## x7 1 18671.3 18671.3 19141.865 < 2.2e-16 \*\*\*  
## x8 1 858.6 858.6 880.262 < 2.2e-16 \*\*\*  
## x9 1 61.4 61.4 62.988 4.201e-15 \*\*\*  
## x5sqrt 1 5071.1 5071.1 5198.875 < 2.2e-16 \*\*\*  
## x7sqrt 1 9911.7 9911.7 10161.556 < 2.2e-16 \*\*\*  
## x8sqrt 1 3155.5 3155.5 3235.044 < 2.2e-16 \*\*\*  
## x9sqrt 1 282.0 282.0 289.134 < 2.2e-16 \*\*\*  
## Residuals 1414 1379.2 1.0   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

**summary**(m3)

##   
## Call:  
## lm(formula = y ~ x2 + x4 + x5 + x7 + x8 + x9 + x5sqrt + x7sqrt +   
## x8sqrt + x9sqrt, data = base)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2.89864 -0.79960 -0.00192 0.83311 3.02275   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.5766526 0.6272645 0.919 0.358088   
## x2 -0.2304361 0.0583390 -3.950 8.20e-05 \*\*\*  
## x4 -0.0705862 0.0040770 -17.313 < 2e-16 \*\*\*  
## x5 -0.3489673 0.0669042 -5.216 2.10e-07 \*\*\*  
## x7 0.3784392 0.1313170 2.882 0.004013 \*\*   
## x8 0.2842105 0.1277121 2.225 0.026212 \*   
## x9 1.1409400 0.1276411 8.939 < 2e-16 \*\*\*  
## x5sqrt 0.0090194 0.0014709 6.132 1.13e-09 \*\*\*  
## x7sqrt -0.0056810 0.0015116 -3.758 0.000178 \*\*\*  
## x8sqrt -0.0030764 0.0012017 -2.560 0.010571 \*   
## x9sqrt -0.0108184 0.0006362 -17.004 < 2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.9876 on 1414 degrees of freedom  
## Multiple R-squared: 0.9817, Adjusted R-squared: 0.9816   
## F-statistic: 7579 on 10 and 1414 DF, p-value: < 2.2e-16