

Caso Practico Unidad 5 Regresión Lineal

Estadística para Científicos de Datos

I. PROBLEMA

El departamento de asistencial de una aseguradora solicita al actuario que indique una fórmula que permita la predicción de los gastos médicos mediante el BMI (el índice de masa corporal, que es una razón matemática que asocia la masa y la talla de un individuo) del asegurado para poder realizar el business case de negocio.

Para realizar el problema, se usará el siguiente dataset:

```
library(tidyverse)
```

```
datos <- read_csv("insurance.csv")
```

Se pide: * Representación gráfica de las observaciones. * Cálculo del modelo de regresión lineal simple.

```
library(hrbrthemes)
library(ggplot2)
```

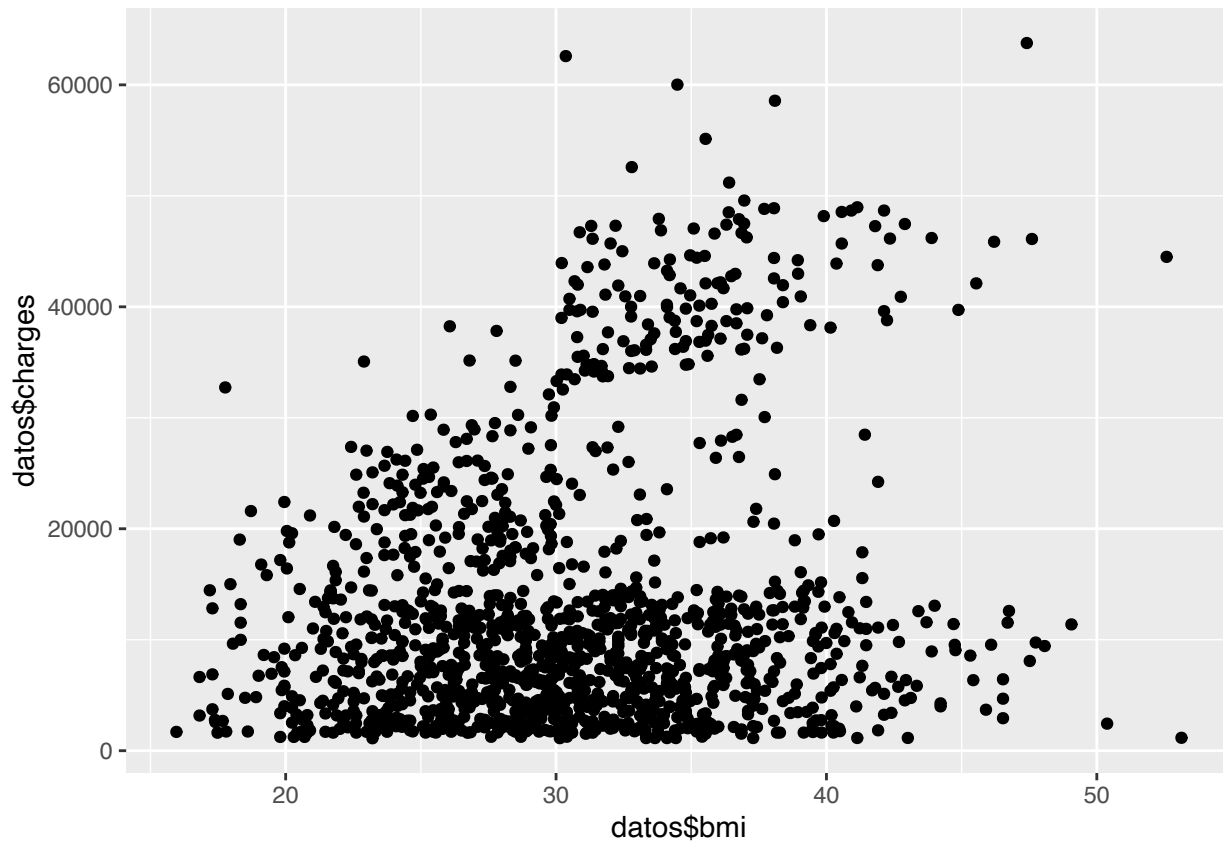
```
## Warning: package 'ggplot2' was built under R version 3.6.2
```

```
library(Cairo)
```

```
## Warning: package 'Cairo' was built under R version 3.6.2
```

```
library(extrafont)
extrafont::loadfonts()

datos <- read_csv("insurance.csv")
qplot(datos$bmi, datos$charges)
```



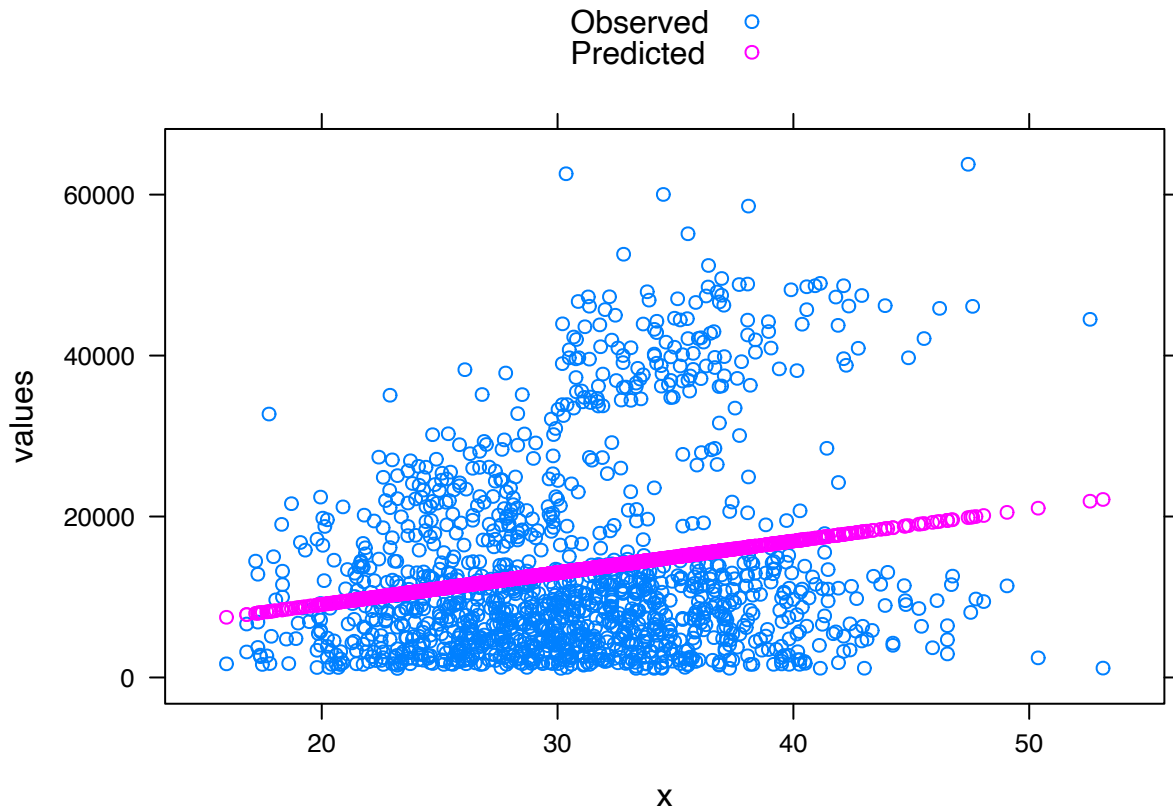
```
fit <- lm(charges ~ bmi, data = datos)
summary(fit)
```

```
##
## Call:
## lm(formula = charges ~ bmi, data = datos)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -20956  -8118  -3757   4722  49442
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1192.94    1664.80   0.717   0.474
## bmi           393.87     53.25   7.397 2.46e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11870 on 1336 degrees of freedom
## Multiple R-squared:  0.03934,    Adjusted R-squared:  0.03862
## F-statistic: 54.71 on 1 and 1336 DF,  p-value: 2.459e-13
```

```
# El siguiente codigo es de https://stackoverflow.com/questions/17432142/plot-the-observed-and-fitted-values
require("lattice")
```

```
## Warning: package 'lattice' was built under R version 3.6.2
```

```
res <- stack(data.frame(Observed = datos$charges, Predicted = fitted(fit)))
res <- cbind(res, x = rep(datos$bmi, 2))
xyplot(values ~ x, data = res, group = ind, auto.key = TRUE)
```



Podemos probar el valor de predicción de nuestro modelo de la siguiente forma:

```
head(datos)
```

```
##   age  sex   bmi children smoker   region   charges
## 1  19 female 27.900         0   yes southwest 16884.924
## 2  18  male 33.770         1   no  southeast  1725.552
## 3  28  male 33.000         3   no  southeast  4449.462
## 4  33  male 22.705         0   no northwest 21984.471
## 5  32  male 28.880         0   no northwest  3866.855
## 6  31 female 25.740         0   no  southeast  3756.622
```

```
predict(fit, newdata = datos[1:5, ])
```

```
##           1           2           3           4           5
## 12181.99 14494.03 14190.75 10135.82 12567.99
```

II. PROBLEMA

Regresión lineal con una variable independiente categórica de dos categorías:

Para hacer este ejercicio, se usará la base de datos Salaries de la librería carData.

```
library(carData)
```

Se da el caso de un departamento de recursos humanos de una consultora especializada en *people analytics* que trabaja para una empresa dedicada a la gestión de colegios privados. Se solicita la predicción del salario de los profesores durante nueve meses en función de las variables que se darán a continuación, para analizar una investigación que evite la presencia de posibles problemas de discriminación.

Se tratará de responder a las siguientes preguntas: * ¿Influye el sexo del profesor en el salario? * ¿Influye el rango del profesor en el salario? * Analizando toda la información disponible, ¿cuáles son las variables más influyentes?

Solución Vamos a revisar las relaciones de los profesores, su sueldos, y su condición de rango y género. Comencemos por ver si los profesores hombre ganan más que sus pares mujeres.

```
library(carData)
```

```
## Warning: package 'carData' was built under R version 3.6.2
```

```
fit <- lm(salary ~ sex, data = Salaries)
summary(fit)
```

```
##
## Call:
## lm(formula = salary ~ sex, data = Salaries)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -57290 -23502  -6828   19710 116455
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   101002      4809   21.001  < 2e-16 ***
## sexMale         14088       5065    2.782  0.00567 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 30030 on 395 degrees of freedom
## Multiple R-squared:  0.01921,    Adjusted R-squared:  0.01673
## F-statistic: 7.738 on 1 and 395 DF,  p-value: 0.005667
```

Por lo que podemos ver, el hecho de ser hombre significa un aumento de 14,088 más que las mujeres. Sigamos con la revisión de rango.

```
summary(Salaries$rank)
```

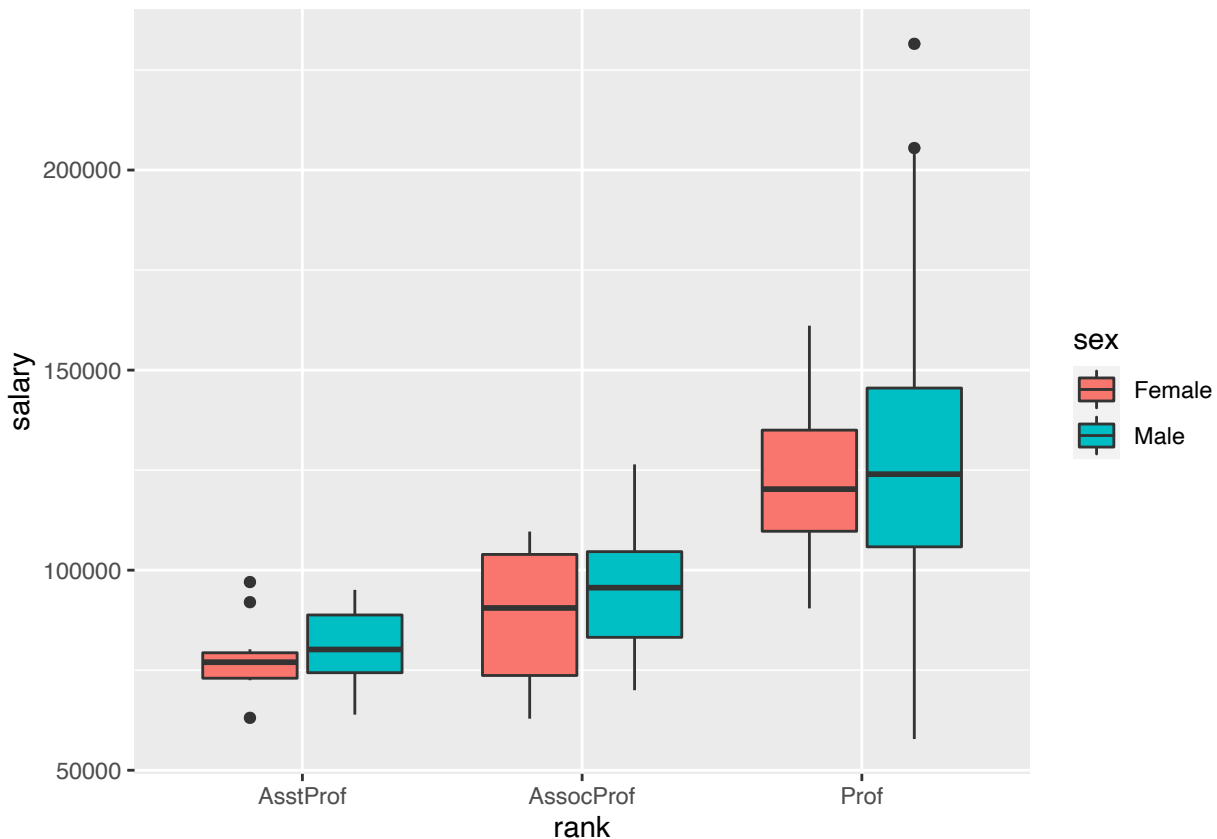
```
##  AsstProf AssocProf      Prof
##       67       64       266
```

```
fit <- lm(salary~rank, data = Salaries)
summary(fit)
```

```
##
## Call:
## lm(formula = salary ~ rank, data = Salaries)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -68972 -16376  -1580   11755  104773
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      80776         2887  27.976 < 2e-16 ***
## rankAssocProf    13100         4131   3.171  0.00164 **
## rankProf         45996         3230  14.238 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 23630 on 394 degrees of freedom
## Multiple R-squared:  0.3943, Adjusted R-squared:  0.3912
## F-statistic: 128.2 on 2 and 394 DF,  p-value: < 2.2e-16
```

Nuevamente, vemos que el salario base es 80,776. Aquellos con un rango de profesor asociado tienen un salario 13,100 más alto, y los que llegan al puesto de profesor 45,996 más alto. Todo esto se visualiza simplemente con un *boxplot*.

```
library(ggplot2)
ggplot(aes(x=rank, y=salary, fill=sex), data=Salaries) + geom_boxplot()
```



PROBLEMA 3

Utilizar el dataset precargado en R de auto para los siguientes ejercicios:

Para cargar el dataset, se utilizará el dataset Auto que esta precargado en el paquete ISLR.

```
library(ISLR)
head(Auto)
```

Este conjunto de datos fue tomado de la biblioteca StatLib, que se mantiene en la Universidad Carnegie Mellon. El conjunto de datos se utilizó en la Exposición de la Asociación Americana de Estadística de 1983. Los datos originales contenían 408 observaciones, pero se eliminaron 16 observaciones con valores faltantes.

Detallar los siguientes apartados: * Exploración de datos iniciales. * Ajuste del modelo con todas las variables. * Herramientas para comprobar las asunciones del modelo. * Selección de las variables mediante el método backward.

Solución Primero hagamos la selección del modelo de ajuste con todas las variables (es un modelo pequeño, no lleva sino segundos).

```
library(ISLR)
fit <- lm(mpg ~ cylinders * displacement + horsepower + acceleration + year + origin + name, data = Auto)
summary(fit)
```

```
##
## Call:
## lm(formula = mpg ~ cylinders * displacement + horsepower + acceleration +
##     year + origin + name, data = Auto)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -5.605   0.000   0.000   0.000   5.605
##
## Coefficients: (1 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    19.74161    13.84191   1.426  0.157468
## cylinders      -4.29109     1.10105  -3.897  0.000193
## displacement  -0.13007     0.03758  -3.461  0.000843
## horsepower     -0.04331     0.02930  -1.478  0.143069
## acceleration  -0.57465     0.16856  -3.409  0.000998
## year           0.59404     0.11035   5.383 6.39e-07
## origin        -0.24843     4.36835  -0.057  0.954781
## nameamc ambassador dpl    3.13089     3.27068   0.957  0.341151
## nameamc ambassador sst    3.54520     3.30073   1.074  0.285832
## nameamc concord          0.74507     3.31144   0.225  0.822520
## nameamc concord d/l      1.15792     3.56594   0.325  0.746193
## nameamc concord dl 6     2.21238     3.60455   0.614  0.541003
## nameamc gremlin          3.56810     3.07514   1.160  0.249173
## nameamc hornet           3.69293     3.02162   1.222  0.225023
## nameamc hornet sportabout (sw) 3.86371     3.70816   1.042  0.300390
## nameamc matador          1.53242     2.74530   0.558  0.578178
## nameamc matador (sw)     1.88780     2.87438   0.657  0.513104
## nameamc pacer            2.69896     3.63392   0.743  0.459703
## nameamc pacer d/l        2.21493     3.64720   0.607  0.545273
```

## nameamc rebel sst	4.02061	3.32056	1.211	0.229318
## nameamc spirit dl	-1.63040	4.12922	-0.395	0.693947
## nameaudi 100 ls	-0.23208	3.41958	-0.068	0.946049
## nameaudi 100ls	-4.47358	2.92597	-1.529	0.129997
## nameaudi 4000	3.68188	3.26637	1.127	0.262826
## nameaudi 5000	-3.46645	3.53274	-0.981	0.329261
## nameaudi 5000s (diesel)	11.66901	3.53049	3.305	0.001391
## nameaudi fox	2.63221	3.34197	0.788	0.433108
## namebmw 2002	2.55685	3.48881	0.733	0.465654
## namebmw 320i	-6.05896	3.36976	-1.798	0.075721
## namebuick century	3.25155	3.15587	1.030	0.305784
## namebuick century 350	1.10404	3.26096	0.339	0.735775
## namebuick century limited	3.23037	3.69039	0.875	0.383852
## namebuick century luxus (sw)	0.28934	3.28760	0.088	0.930076
## namebuick century special	2.44092	3.57049	0.684	0.496064
## namebuick electra 225 custom	1.59536	3.43878	0.464	0.643881
## namebuick estate wagon (sw)	3.23418	2.87351	1.126	0.263539
## namebuick lesabre custom	1.11929	3.27500	0.342	0.733368
## namebuick opel isuzu deluxe	1.36974	4.16163	0.329	0.742863
## namebuick regal sport coupe (turbo)	0.76008	3.77244	0.201	0.840804
## namebuick skyhawk	4.37984	3.57196	1.226	0.223519
## namebuick skylark	1.47268	3.33139	0.442	0.659568
## namebuick skylark 320	3.59112	3.26658	1.099	0.274718
## namebuick skylark limited	2.39634	3.97724	0.603	0.548437
## namecadillac eldorado	7.90300	3.45418	2.288	0.024623
## namecadillac seville	2.52125	3.27987	0.769	0.444198
## namecapri ii	-0.50736	4.00996	-0.127	0.899615
## namechevrolet chevelle malibu	1.85698	3.58069	0.519	0.605382
## namechevrolet bel air	1.19144	3.29983	0.361	0.718949
## namechevrolet camaro	-0.03874	3.99879	-0.010	0.992294
## namechevrolet caprice classic	0.62575	2.71681	0.230	0.818392
## namechevrolet cavalier	-0.42838	4.17347	-0.103	0.918488
## namechevrolet cavalier 2-door	4.65217	4.17979	1.113	0.268840
## namechevrolet cavalier wagon	-2.00303	4.17538	-0.480	0.632656
## namechevrolet chevelle concours (sw)	0.12931	3.34579	0.039	0.969261
## namechevrolet chevelle malibu	4.23037	3.09932	1.365	0.175876
## namechevrolet chevelle malibu classic	1.73750	2.98003	0.583	0.561405
## namechevrolet chevette	1.22917	3.71125	0.331	0.741309
## namechevrolet citation	2.45133	3.30258	0.742	0.459983
## namechevrolet concours	1.17865	3.56343	0.331	0.741638
## namechevrolet impala	1.45108	2.60387	0.557	0.578803
## namechevrolet malibu	0.98928	2.94313	0.336	0.737599
## namechevrolet malibu classic (sw)	2.34806	3.39983	0.691	0.491672
## namechevrolet monte carlo	2.01859	3.53591	0.571	0.569584
## namechevrolet monte carlo landau	1.51889	2.85214	0.533	0.595741
## namechevrolet monte carlo s	1.80487	3.30671	0.546	0.586619
## namechevrolet monza 2+2	3.99003	3.44678	1.158	0.250266
## namechevrolet nova	2.58572	3.09039	0.837	0.405109
## namechevrolet nova custom	2.54120	3.62925	0.700	0.485714
## namechevrolet vega	-0.12368	3.47901	-0.036	0.971725
## namechevrolet vega (sw)	0.95282	3.98742	0.239	0.811715
## namechevrolet vega 2300	5.72103	4.00530	1.428	0.156852
## namechevrolet woody	-1.08226	4.14447	-0.261	0.794621
## namechevy c10	-2.55191	3.31161	-0.771	0.443085

## namechevy c20	1.92343	3.67727	0.523	0.602294
## namechevy s-10	2.66797	4.10974	0.649	0.517972
## namechrysler cordoba	1.64409	3.32008	0.495	0.621738
## namechrysler lebaron medallion	-2.22465	4.06536	-0.547	0.585661
## namechrysler lebaron salon	-2.96308	3.66221	-0.809	0.420720
## namechrysler lebaron town @ country (sw)	2.00243	3.32977	0.601	0.549193
## namechrysler new yorker brougham	2.09440	3.37472	0.621	0.536514
## namechrysler newport royal	2.28669	3.28952	0.695	0.488860
## namedatsun 1200	9.16865	6.55078	1.400	0.165264
## namedatsun 200-sx	-3.49537	6.58318	-0.531	0.596835
## namedatsun 200sx	3.79496	6.56187	0.578	0.564567
## namedatsun 210	6.81058	6.28773	1.083	0.281803
## namedatsun 210 mpg	6.73445	6.48747	1.038	0.302182
## namedatsun 280-zx	10.22788	7.23445	1.414	0.161080
## namedatsun 310	5.87183	6.37332	0.921	0.359494
## namedatsun 310 gx	5.79193	6.37528	0.908	0.366184
## namedatsun 510	-0.31030	6.57568	-0.047	0.962473
## namedatsun 510 (sw)	3.67850	6.65202	0.553	0.581721
## namedatsun 510 hatchback	8.25749	6.54914	1.261	0.210813
## namedatsun 610	-2.37594	6.66613	-0.356	0.722409
## namedatsun 710	2.47429	6.42262	0.385	0.701017
## namedatsun 810	0.78563	7.18588	0.109	0.913198
## namedatsun 810 maxima	1.20324	7.19937	0.167	0.867664
## namedatsun b-210	3.54201	6.45585	0.549	0.584683
## namedatsun b210	4.34568	6.55216	0.663	0.508969
## namedatsun b210 gx	10.67338	6.49616	1.643	0.104071
## namedatsun f-10 hatchback	4.33304	6.43147	0.674	0.502315
## namedatsun pl510	1.95971	6.36872	0.308	0.759057
## namedodge aries se	-0.12244	4.08767	-0.030	0.976175
## namedodge aries wagon (sw)	-1.88808	4.04879	-0.466	0.642172
## namedodge aspen	1.33136	3.17380	0.419	0.675920
## namedodge aspen 6	2.30764	3.55587	0.649	0.518110
## namedodge aspen se	3.68883	3.56184	1.036	0.303301
## namedodge challenger se	3.09507	3.30171	0.937	0.351201
## namedodge charger 2.2	5.15360	4.20476	1.226	0.223712
## namedodge colt	-0.18979	3.66182	-0.052	0.958785
## namedodge colt (sw)	1.57997	4.21236	0.375	0.708536
## namedodge colt hardtop	-0.30438	4.16960	-0.073	0.941978
## namedodge colt hatchback custom	4.77689	4.28249	1.115	0.267803
## namedodge colt m/m	4.75687	4.21049	1.130	0.261753
## namedodge coronet brougham	1.09440	3.27462	0.334	0.739046
## namedodge coronet custom	1.58920	3.27264	0.486	0.628499
## namedodge coronet custom (sw)	0.56981	3.27194	0.174	0.862161
## namedodge d100	-1.33094	3.28055	-0.406	0.685977
## namedodge d200	2.54431	3.66590	0.694	0.489546
## namedodge dart custom	0.72722	3.28500	0.221	0.825331
## namedodge diplomat	2.98820	3.30716	0.904	0.368785
## namedodge magnum xe	1.37553	3.30588	0.416	0.678397
## namedodge monaco (sw)	0.79606	3.25822	0.244	0.807568
## namedodge monaco brougham	0.18609	3.28789	0.057	0.954997
## namedodge omni	0.88297	4.22567	0.209	0.834984
## namedodge rampage	0.34909	4.27881	0.082	0.935169
## namedodge st. regis	2.12694	3.33474	0.638	0.525310
## namefiat 124 sport coupe	-0.04526	3.35620	-0.013	0.989272

## namefiat 124 tc	-0.93945	3.34286	-0.281	0.779369
## namefiat 124b	3.28888	3.35441	0.980	0.329639
## namefiat 128	-1.18424	2.93016	-0.404	0.687113
## namefiat 131	0.60510	3.30349	0.183	0.855100
## namefiat strada custom	5.85025	3.24018	1.806	0.074532
## namefiat x1.9	2.37328	3.30480	0.718	0.474645
## nameford country	-0.30337	3.32697	-0.091	0.927560
## nameford country squire (sw)	0.54479	2.88065	0.189	0.850448
## nameford escort 2h	0.75954	4.19896	0.181	0.856886
## nameford escort 4w	2.67360	4.27647	0.625	0.533523
## nameford f108	-1.69483	3.32489	-0.510	0.611554
## nameford f250	2.23830	3.55695	0.629	0.530856
## nameford fairmont	0.18215	3.98446	0.046	0.963645
## nameford fairmont (auto)	0.06147	3.64386	0.017	0.986580
## nameford fairmont (man)	-1.48134	4.01614	-0.369	0.713160
## nameford fairmont 4	-3.78354	3.98166	-0.950	0.344684
## nameford fairmont futura	-4.20962	4.05752	-1.037	0.302451
## nameford fiesta	5.16465	4.29308	1.203	0.232310
## nameford futura	0.42315	3.34292	0.127	0.899572
## nameford galaxie 500	2.96567	2.69039	1.102	0.273433
## nameford gran torino	1.05675	2.69797	0.392	0.696274
## nameford gran torino (sw)	1.59500	2.91380	0.547	0.585541
## nameford granada	3.15308	3.59703	0.877	0.383186
## nameford granada ghia	3.53032	3.73272	0.946	0.346943
## nameford granada gl	-0.84368	3.62547	-0.233	0.816546
## nameford granada l	1.17169	3.62154	0.324	0.747087
## nameford ltd	0.20547	2.84101	0.072	0.942516
## nameford ltd landau	0.16029	3.35293	0.048	0.961983
## nameford maverick	3.70038	3.11519	1.188	0.238201
## nameford mustang	3.19833	3.83912	0.833	0.407129
## nameford mustang gl	-1.92918	4.07933	-0.473	0.637485
## nameford mustang ii	-2.86806	3.35146	-0.856	0.394534
## nameford mustang ii 2+2	-0.21413	3.99356	-0.054	0.957365
## nameford pinto	-1.32881	3.33080	-0.399	0.690933
## nameford pinto (sw)	-1.97033	4.05278	-0.486	0.628100
## nameford pinto runabout	-2.68300	4.04182	-0.664	0.508609
## nameford ranger	-0.85437	4.10604	-0.208	0.835666
## nameford thunderbird	1.46844	3.29973	0.445	0.657438
## nameford torino	3.71652	3.37355	1.102	0.273717
## nameford torino 500	4.77298	3.80563	1.254	0.213211
## namehi 1200d	2.61800	3.82554	0.684	0.495617
## namehonda accord	3.68568	6.25246	0.589	0.557105
## namehonda accord cvcc	4.09825	6.56184	0.625	0.533934
## namehonda accord lx	0.41237	6.46831	0.064	0.949317
## namehonda civic	2.88246	6.19290	0.465	0.642802
## namehonda civic (auto)	-0.49540	6.35811	-0.078	0.938078
## namehonda civic 1300	2.45236	6.32469	0.388	0.699175
## namehonda civic 1500 gl	12.20084	6.31908	1.931	0.056842
## namehonda civic cvcc	5.58544	6.25549	0.893	0.374439
## namehonda prelude	2.47485	6.41814	0.386	0.700754
## namemaxda glc deluxe	2.67628	6.34387	0.422	0.674186
## namemaxda rx3	-14.02311	6.20840	-2.259	0.026460
## namemazda 626	3.38642	6.42089	0.527	0.599285
## namemazda glc	16.13381	6.43260	2.508	0.014037

## namemazda glc 4	2.41435	6.37739	0.379	0.705945
## namemazda glc custom	-0.36025	6.43128	-0.056	0.955461
## namemazda glc custom l	5.98454	6.45703	0.927	0.356641
## namemazda glc deluxe	3.28249	6.46917	0.507	0.613184
## namemazda rx-4	-11.20322	6.27599	-1.785	0.077814
## namemazda rx-7 gs	-12.62299	6.15153	-2.052	0.043246
## namemazda rx2 coupe	-12.12593	6.25245	-1.939	0.055771
## name Mercedes-benz 240d	5.65119	3.61531	1.563	0.121738
## name Mercedes-benz 280s	-1.31838	3.95140	-0.334	0.739466
## name Mercedes benz 300d	5.01070	3.85593	1.299	0.197293
## name Mercury capri 2000	-1.52559	4.11977	-0.370	0.712073
## name Mercury capri v6	2.13388	3.73638	0.571	0.569432
## name Mercury cougar brougham	-0.34634	3.32775	-0.104	0.917354
## name Mercury grand marquis	-0.44305	3.36598	-0.132	0.895590
## name Mercury lynx l	4.52821	4.26299	1.062	0.291147
## name Mercury marquis	0.33550	3.33322	0.101	0.920062
## name Mercury marquis brougham	0.59573	3.33331	0.179	0.858582
## name Mercury monarch	0.86453	3.79735	0.228	0.820452
## name Mercury monarch ghia	3.44259	3.32017	1.037	0.302737
## name Mercury zephyr	1.17866	3.62269	0.325	0.745712
## name Mercury zephyr 6	0.44660	3.60458	0.124	0.901688
## name Nissan stanza xe	5.67616	6.51108	0.872	0.385790
## name Oldsmobile cutlass ciera (diesel)	18.40157	3.75859	4.896	4.61e-06
## name Oldsmobile cutlass ls	10.36825	3.64434	2.845	0.005563
## name Oldsmobile cutlass salon brougham	6.44317	3.09595	2.081	0.040428
## name Oldsmobile cutlass supreme	2.95349	3.47296	0.850	0.397478
## name Oldsmobile delta 88 royale	0.33582	3.26481	0.103	0.918315
## name Oldsmobile omega	-1.82875	3.24962	-0.563	0.575083
## name Oldsmobile omega brougham	4.73042	3.73274	1.267	0.208517
## name Oldsmobile starfire sx	-0.90670	3.93526	-0.230	0.818330
## name Oldsmobile vista cruiser	0.03324	3.26637	0.010	0.991905
## name Opel 1900	1.14553	2.94532	0.389	0.698299
## name Opel manta	-1.64217	2.90515	-0.565	0.573383
## name Peugeot 304	5.29661	3.49661	1.515	0.133537
## name Peugeot 504	0.45921	2.91907	0.157	0.875371
## name Peugeot 504 (sw)	-0.80190	3.55905	-0.225	0.822277
## name Peugeot 505s turbo diesel	2.57910	3.53164	0.730	0.467224
## name Peugeot 604sl	-2.94025	3.99817	-0.735	0.464120
## name Plymouth 'cuda 340	0.31803	3.34243	0.095	0.924420
## name Plymouth arrow gs	-1.29480	4.08255	-0.317	0.751904
## name Plymouth champ	6.53761	4.35342	1.502	0.136876
## name Plymouth cricket	2.43044	4.19423	0.579	0.563802
## name Plymouth custom suburb	0.93278	3.25150	0.287	0.774904
## name Plymouth duster	5.37053	3.11066	1.726	0.087892
## name Plymouth fury	2.81339	3.58353	0.785	0.434583
## name Plymouth fury gran sedan	1.73851	3.28649	0.529	0.598194
## name Plymouth fury iii	2.75413	2.65723	1.036	0.302924
## name Plymouth grand fury	2.55043	3.28296	0.777	0.439393
## name Plymouth horizon	2.62535	4.31001	0.609	0.544063
## name Plymouth horizon 4	2.61104	4.29053	0.609	0.544439
## name Plymouth horizon miser	5.20207	4.31957	1.204	0.231815
## name Plymouth horizon tc3	3.90226	4.23529	0.921	0.359466
## name Plymouth reliant	-0.90531	3.79460	-0.239	0.812007
## name Plymouth sapporo	-0.82128	3.94214	-0.208	0.835467

## nameplymouth satellite	5.50934	3.31448	1.662	0.100156
## nameplymouth satellite custom	1.61132	3.62662	0.444	0.657952
## nameplymouth satellite custom (sw)	2.04522	3.28695	0.622	0.535460
## nameplymouth satellite sebring	2.40386	3.56948	0.673	0.502490
## nameplymouth valiant	3.68251	3.19409	1.153	0.252177
## nameplymouth valiant custom	2.08943	3.61138	0.579	0.564410
## nameplymouth volare	2.71342	3.56386	0.761	0.448543
## nameplymouth volare custom	2.09479	3.55932	0.589	0.557733
## nameplymouth volare premier v8	-1.79066	3.27511	-0.547	0.585983
## namepontiac astro	-0.45084	3.94659	-0.114	0.909320
## namepontiac catalina	3.07214	2.72719	1.126	0.263129
## namepontiac catalina brougham	2.65650	3.30332	0.804	0.423531
## namepontiac firebird	5.00532	3.71433	1.348	0.181378
## namepontiac grand prix	4.70091	3.43792	1.367	0.175115
## namepontiac grand prix lj	1.07892	3.30820	0.326	0.745124
## namepontiac j2000 se hatchback	0.48788	4.20291	0.116	0.907862
## namepontiac lemans v6	2.95007	3.56295	0.828	0.409997
## namepontiac phoenix	3.12541	3.67072	0.851	0.396916
## namepontiac phoenix lj	2.99474	3.55614	0.842	0.402076
## namepontiac safari (sw)	1.94383	3.30510	0.588	0.558005
## namepontiac sunbird coupe	-0.40219	3.96084	-0.102	0.919359
## namepontiac ventura sj	2.65776	3.56808	0.745	0.458405
## namerenault 12 (sw)	0.94140	3.41049	0.276	0.783194
## namerenault 12tl	-1.04355	3.28570	-0.318	0.751564
## namerenault 5 gtl	6.69551	3.32386	2.014	0.047132
## namesaab 99e	2.50650	3.52710	0.711	0.479252
## namesaab 99gle	-4.66998	3.48241	-1.341	0.183487
## namesaab 99le	-0.62265	3.02166	-0.206	0.837234
## namesubaru	1.21064	6.31872	0.192	0.848516
## namesubaru dl	2.74953	6.27205	0.438	0.662224
## nametoyota carina	-3.93945	6.71606	-0.587	0.559046
## nametoyota celica gt	3.29303	6.66157	0.494	0.622347
## nametoyota celica gt liftback	-5.42993	6.66314	-0.815	0.417395
## nametoyota corolla	1.99847	6.15109	0.325	0.746057
## nametoyota corolla 1200	5.68638	6.39893	0.889	0.376702
## nametoyota corolla 1600 (sw)	2.21796	6.61528	0.335	0.738242
## nametoyota corolla liftback	-1.33831	6.55851	-0.204	0.838797
## nametoyota corolla tercel	8.13637	6.47603	1.256	0.212419
## nametoyota corona	0.49665	6.26397	0.079	0.936991
## nametoyota corona hardtop	0.02326	6.67481	0.003	0.997228
## nametoyota corona liftback	2.26772	6.65217	0.341	0.734021
## nametoyota corona mark ii	0.92401	6.70459	0.138	0.890711
## nametoyota cressida	2.33054	7.19911	0.324	0.746941
## nametoyota mark ii	0.90938	7.14140	0.127	0.898973
## nametoyota starlet	6.69087	6.34188	1.055	0.294401
## nametoyota tercel	6.36696	6.40675	0.994	0.323146
## nametoyouta corona mark ii (sw)	-0.99368	6.68136	-0.149	0.882123
## nametriumph tr7 coupe	6.09520	3.31146	1.841	0.069164
## namevolkswagen rabbit	-2.33674	3.24695	-0.720	0.473701
## namevolkswagen 1131 deluxe sedan	2.63739	3.61073	0.730	0.467135
## namevolkswagen 411 (sw)	-1.07294	3.47976	-0.308	0.758580
## namevolkswagen dasher	-1.74895	2.68698	-0.651	0.516868
## namevolkswagen jetta	1.23358	3.25612	0.379	0.705744
## namevolkswagen model 111	2.78765	3.48259	0.800	0.425681

## namevolkswagen rabbit	-0.80684	2.84006	-0.284	0.777029
## namevolkswagen rabbit custom	-0.58305	3.25411	-0.179	0.858229
## namevolkswagen rabbit custom diesel	15.17522	3.43065	4.423	2.86e-05
## namevolkswagen rabbit l	4.27166	3.26889	1.307	0.194819
## namevolkswagen scirocco	0.71123	3.24389	0.219	0.826979
## namevolkswagen super beetle	1.14260	3.52787	0.324	0.746827
## namevolkswagen type 3	0.51972	3.67538	0.141	0.887885
## namevolvo 144ea	-4.54462	3.49358	-1.301	0.196826
## namevolvo 145e (sw)	-5.52523	3.47946	-1.588	0.116009
## namevolvo 244dl	-3.91363	3.35844	-1.165	0.247152
## namevolvo 245	-5.03916	3.41581	-1.475	0.143841
## namevolvo 264gl	-3.75094	3.83217	-0.979	0.330456
## namevolvo diesel	8.84644	3.81051	2.322	0.022648
## namevw dasher (diesel)	15.55138	3.53410	4.400	3.12e-05
## namevw pickup	16.12482	3.60048	4.479	2.32e-05
## namevw rabbit	4.62575	2.80994	1.646	0.103413
## namevw rabbit c (diesel)	15.30207	3.42506	4.468	2.42e-05
## namevw rabbit custom	NA	NA	NA	NA
## cylinders:displacement	0.01569	0.00484	3.242	0.001695
##				
## (Intercept)				
## cylinders	***			
## displacement	***			
## horsepower				
## acceleration	***			
## year	***			
## origin				
## nameamc ambassador dpl				
## nameamc ambassador sst				
## nameamc concord				
## nameamc concord d/l				
## nameamc concord dl 6				
## nameamc gremlin				
## nameamc hornet				
## nameamc hornet sportabout (sw)				
## nameamc matador				
## nameamc matador (sw)				
## nameamc pacer				
## nameamc pacer d/l				
## nameamc rebel sst				
## nameamc spirit dl				
## nameaudi 100 ls				
## nameaudi 100ls				
## nameaudi 4000				
## nameaudi 5000				
## nameaudi 5000s (diesel)	**			
## nameaudi fox				
## namebmw 2002				
## namebmw 320i	.			
## namebuick century				
## namebuick century 350				
## namebuick century limited				
## namebuick century luxus (sw)				
## namebuick century special				

```

## namebuick electra 225 custom
## namebuick estate wagon (sw)
## namebuick lesabre custom
## namebuick opel isuzu deluxe
## namebuick regal sport coupe (turbo)
## namebuick skyhawk
## namebuick skylark
## namebuick skylark 320
## namebuick skylark limited
## namecadillac eldorado *
## namecadillac seville
## namecapri ii
## namechevrolet chevelle malibu
## namechevrolet bel air
## namechevrolet camaro
## namechevrolet caprice classic
## namechevrolet cavalier
## namechevrolet cavalier 2-door
## namechevrolet cavalier wagon
## namechevrolet chevelle concours (sw)
## namechevrolet chevelle malibu
## namechevrolet chevelle malibu classic
## namechevrolet chevette
## namechevrolet citation
## namechevrolet concours
## namechevrolet impala
## namechevrolet malibu
## namechevrolet malibu classic (sw)
## namechevrolet monte carlo
## namechevrolet monte carlo landau
## namechevrolet monte carlo s
## namechevrolet monza 2+2
## namechevrolet nova
## namechevrolet nova custom
## namechevrolet vega
## namechevrolet vega (sw)
## namechevrolet vega 2300
## namechevrolet woody
## namechevy c10
## namechevy c20
## namechevy s-10
## namechrysler cordoba
## namechrysler lebaron medallion
## namechrysler lebaron salon
## namechrysler lebaron town @ country (sw)
## namechrysler new yorker brougham
## namechrysler newport royal
## namedatsun 1200
## namedatsun 200-sx
## namedatsun 200sx
## namedatsun 210
## namedatsun 210 mpg
## namedatsun 280-zx
## namedatsun 310

```

```

## namedatsun 310 gx
## namedatsun 510
## namedatsun 510 (sw)
## namedatsun 510 hatchback
## namedatsun 610
## namedatsun 710
## namedatsun 810
## namedatsun 810 maxima
## namedatsun b-210
## namedatsun b210
## namedatsun b210 gx
## namedatsun f-10 hatchback
## namedatsun pl510
## namedodge aries se
## namedodge aries wagon (sw)
## namedodge aspen
## namedodge aspen 6
## namedodge aspen se
## namedodge challenger se
## namedodge charger 2.2
## namedodge colt
## namedodge colt (sw)
## namedodge colt hardtop
## namedodge colt hatchback custom
## namedodge colt m/m
## namedodge coronet brougham
## namedodge coronet custom
## namedodge coronet custom (sw)
## namedodge d100
## namedodge d200
## namedodge dart custom
## namedodge diplomat
## namedodge magnum xe
## namedodge monaco (sw)
## namedodge monaco brougham
## namedodge omni
## namedodge rampage
## namedodge st. regis
## namefiat 124 sport coupe
## namefiat 124 tc
## namefiat 124b
## namefiat 128
## namefiat 131
## namefiat strada custom
## namefiat x1.9
## nameford country
## nameford country squire (sw)
## nameford escort 2h
## nameford escort 4w
## nameford f108
## nameford f250
## nameford fairmont
## nameford fairmont (auto)
## nameford fairmont (man)

```

```

## nameford fairmont 4
## nameford fairmont futura
## nameford fiesta
## nameford futura
## nameford galaxie 500
## nameford gran torino
## nameford gran torino (sw)
## nameford granada
## nameford granada ghia
## nameford granada gl
## nameford granada l
## nameford ltd
## nameford ltd landau
## nameford maverick
## nameford mustang
## nameford mustang gl
## nameford mustang ii
## nameford mustang ii 2+2
## nameford pinto
## nameford pinto (sw)
## nameford pinto runabout
## nameford ranger
## nameford thunderbird
## nameford torino
## nameford torino 500
## namehi 1200d
## namehonda accord
## namehonda accord cvcc
## namehonda accord lx
## namehonda civic
## namehonda civic (auto)
## namehonda civic 1300
## namehonda civic 1500 gl .
## namehonda civic cvcc
## namehonda prelude
## namemaxda glc deluxe
## namemaxda rx3 *
## namemazda 626
## namemazda glc *
## namemazda glc 4
## namemazda glc custom
## namemazda glc custom l
## namemazda glc deluxe
## namemazda rx-4 .
## namemazda rx-7 gs *
## namemazda rx2 coupe .
## namemercedes-benz 240d
## namemercedes-benz 280s
## namemercedes benz 300d
## namemercury capri 2000
## namemercury capri v6
## namemercury cougar brougham
## namemercury grand marquis
## namemercury lynx l

```

```

## namemercury marquis
## namemercury marquis brougham
## namemercury monarch
## namemercury monarch ghia
## namemercury zephyr
## namemercury zephyr 6
## namenissan stanza xe
## nameoldsmobile cutlass ciera (diesel)    ***
## nameoldsmobile cutlass ls                **
## nameoldsmobile cutlass salon brougham    *
## nameoldsmobile cutlass supreme
## nameoldsmobile delta 88 royale
## nameoldsmobile omega
## nameoldsmobile omega brougham
## nameoldsmobile starfire sx
## nameoldsmobile vista cruiser
## nameopel 1900
## nameopel manta
## namepeugeot 304
## namepeugeot 504
## namepeugeot 504 (sw)
## namepeugeot 505s turbo diesel
## namepeugeot 604sl
## nameplymouth 'cuda 340
## nameplymouth arrow gs
## nameplymouth champ
## nameplymouth cricket
## nameplymouth custom suburb
## nameplymouth duster
## nameplymouth fury
## nameplymouth fury gran sedan
## nameplymouth fury iii
## nameplymouth grand fury
## nameplymouth horizon
## nameplymouth horizon 4
## nameplymouth horizon miser
## nameplymouth horizon tc3
## nameplymouth reliant
## nameplymouth sapporo
## nameplymouth satellite
## nameplymouth satellite custom
## nameplymouth satellite custom (sw)
## nameplymouth satellite sebring
## nameplymouth valiant
## nameplymouth valiant custom
## nameplymouth volare
## nameplymouth volare custom
## nameplymouth volare premier v8
## namepontiac astro
## namepontiac catalina
## namepontiac catalina brougham
## namepontiac firebird
## namepontiac grand prix
## namepontiac grand prix lj

```



```

## namepontiac j2000 se hatchback
## namepontiac lemans v6
## namepontiac phoenix
## namepontiac phoenix lj
## namepontiac safari (sw)
## namepontiac sunbird coupe
## namepontiac ventura sj
## namerenault 12 (sw)
## namerenault 12tl
## namerenault 5 gtl *
## namesaab 99e
## namesaab 99gle
## namesaab 99le
## namesubaru
## namesubaru dl
## nametoyota carina
## nametoyota celica gt
## nametoyota celica gt liftback
## nametoyota corolla
## nametoyota corolla 1200
## nametoyota corolla 1600 (sw)
## nametoyota corolla liftback
## nametoyota corolla tercel
## nametoyota corona
## nametoyota corona hardtop
## nametoyota corona liftback
## nametoyota corona mark ii
## nametoyota cressida
## nametoyota mark ii
## nametoyota starlet
## nametoyota tercel
## nametoyouta corona mark ii (sw)
## nametriumph tr7 coupe .
## namevolkswagen rabbit
## namevolkswagen 1131 deluxe sedan
## namevolkswagen 411 (sw)
## namevolkswagen dasher
## namevolkswagen jetta
## namevolkswagen model 111
## namevolkswagen rabbit
## namevolkswagen rabbit custom
## namevolkswagen rabbit custom diesel ***
## namevolkswagen rabbit l
## namevolkswagen scirocco
## namevolkswagen super beetle
## namevolkswagen type 3
## namevolvo 144ea
## namevolvo 145e (sw)
## namevolvo 244dl
## namevolvo 245
## namevolvo 264gl
## namevolvo diesel *
## namevw dasher (diesel) ***
## namevw pickup ***

```

```
## namevw rabbit
## namevw rabbit c (diesel)          ***
## namevw rabbit custom
## cylinders:displacement            **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.29 on 85 degrees of freedom
## Multiple R-squared:  0.9813, Adjusted R-squared:  0.9139
## F-statistic: 14.57 on 306 and 85 DF,  p-value: < 2.2e-16
```

Ahora que tenemos el modelo completo, usemos StepAIC para reducirlo.

```
step(object = fit, direction = "backward", trace = 1)
```

```
## Start:  AIC=664.27
## mpg ~ cylinders * displacement + horsepower + acceleration +
##      year + origin + name
##
##
## Step:  AIC=664.27
## mpg ~ cylinders + displacement + horsepower + acceleration +
##      year + name + cylinders:displacement
##
##              Df Sum of Sq    RSS    AIC
## <none>                445.6 664.27
## - horsepower           1     11.5  457.1 672.22
## - cylinders:displacement 1     55.1  500.8 707.98
## - acceleration         1     60.9  506.6 712.51
## - year                 1    151.9  597.6 777.27
## - name                 300   3944.2 4389.9 960.99

##
## Call:
## lm(formula = mpg ~ cylinders + displacement + horsepower + acceleration +
##      year + name + cylinders:displacement, data = Auto)
##
## Coefficients:
##              (Intercept)
##              1.949e+01
##              cylinders
##             -4.291e+00
##             displacement
##             -1.301e-01
##             horsepower
##             -4.331e-02
##             acceleration
##             -5.747e-01
##              year
##              5.940e-01
##      nameamc ambassador dpl
##              3.131e+00
##      nameamc ambassador sst
```

```

##          3.545e+00
##      nameamc concord
##          7.451e-01
##      nameamc concord d/l
##          1.158e+00
##      nameamc concord dl 6
##          2.212e+00
##      nameamc gremlin
##          3.568e+00
##      nameamc hornet
##          3.693e+00
##      nameamc hornet sportabout (sw)
##          3.864e+00
##      nameamc matador
##          1.532e+00
##      nameamc matador (sw)
##          1.888e+00
##      nameamc pacer
##          2.699e+00
##      nameamc pacer d/l
##          2.215e+00
##      nameamc rebel sst
##          4.021e+00
##      nameamc spirit dl
##          -1.630e+00
##      nameaudi 100 ls
##          -4.805e-01
##      nameaudi 100ls
##          -4.722e+00
##      nameaudi 4000
##          3.433e+00
##      nameaudi 5000
##          -3.715e+00
##      nameaudi 5000s (diesel)
##          1.142e+01
##      nameaudi fox
##          2.384e+00
##      namebmw 2002
##          2.308e+00
##      namebmw 320i
##          -6.307e+00
##      namebuick century
##          3.252e+00
##      namebuick century 350
##          1.104e+00
##      namebuick century limited
##          3.230e+00
##      namebuick century luxus (sw)
##          2.893e-01
##      namebuick century special
##          2.441e+00
##      namebuick electra 225 custom
##          1.595e+00
##      namebuick estate wagon (sw)

```

```

##                3.234e+00
##      namebuick lesabre custom
##                1.119e+00
##      namebuick opel isuzu deluxe
##                1.370e+00
##      namebuick regal sport coupe (turbo)
##                7.601e-01
##      namebuick skyhawk
##                4.380e+00
##      namebuick skylark
##                1.473e+00
##      namebuick skylark 320
##                3.591e+00
##      namebuick skylark limited
##                2.396e+00
##      namecadillac eldorado
##                7.903e+00
##      namecadillac seville
##                2.521e+00
##      namecapri ii
##                -5.074e-01
##      namechevroelt chevelle malibu
##                1.857e+00
##      namechevrolet bel air
##                1.191e+00
##      namechevrolet camaro
##                -3.874e-02
##      namechevrolet caprice classic
##                6.257e-01
##      namechevrolet cavalier
##                -4.284e-01
##      namechevrolet cavalier 2-door
##                4.652e+00
##      namechevrolet cavalier wagon
##                -2.003e+00
##      namechevrolet chevelle concours (sw)
##                1.293e-01
##      namechevrolet chevelle malibu
##                4.230e+00
##      namechevrolet chevelle malibu classic
##                1.738e+00
##      namechevrolet chevette
##                1.229e+00
##      namechevrolet citation
##                2.451e+00
##      namechevrolet concours
##                1.179e+00
##      namechevrolet impala
##                1.451e+00
##      namechevrolet malibu
##                9.893e-01
##      namechevrolet malibu classic (sw)
##                2.348e+00
##      namechevrolet monte carlo

```

```

##                2.019e+00
##    namechevrolet monte carlo landau
##                1.519e+00
##        namechevrolet monte carlo s
##                1.805e+00
##            namechevrolet monza 2+2
##                3.990e+00
##                namechevrolet nova
##                2.586e+00
##        namechevrolet nova custom
##                2.541e+00
##            namechevrolet vega
##                -1.237e-01
##        namechevrolet vega (sw)
##                9.528e-01
##        namechevrolet vega 2300
##                5.721e+00
##            namechevrolet woody
##                -1.082e+00
##                namechevy c10
##                -2.552e+00
##                namechevy c20
##                1.923e+00
##                namechevy s-10
##                2.668e+00
##        namechrysler cordoba
##                1.644e+00
##        namechrysler lebaron medallion
##                -2.225e+00
##        namechrysler lebaron salon
##                -2.963e+00
## namechrysler lebaron town @ country (sw)
##                2.002e+00
##        namechrysler new yorker brougham
##                2.094e+00
##        namechrysler newport royal
##                2.287e+00
##                namedatsun 1200
##                8.672e+00
##                namedatsun 200-sx
##                -3.992e+00
##                namedatsun 200sx
##                3.298e+00
##                namedatsun 210
##                6.314e+00
##                namedatsun 210 mpg
##                6.238e+00
##                namedatsun 280-zx
##                9.731e+00
##                namedatsun 310
##                5.375e+00
##                namedatsun 310 gx
##                5.295e+00
##                namedatsun 510

```

```

##                -8.072e-01
##          namedatsun 510 (sw)
##                3.182e+00
##    namedatsun 510 hatchback
##                7.761e+00
##          namedatsun 610
##                -2.873e+00
##          namedatsun 710
##                1.977e+00
##          namedatsun 810
##                2.888e-01
##    namedatsun 810 maxima
##                7.064e-01
##          namedatsun b-210
##                3.045e+00
##          namedatsun b210
##                3.849e+00
##    namedatsun b210 gx
##                1.018e+01
##    namedatsun f-10 hatchback
##                3.836e+00
##          namedatsun pl510
##                1.463e+00
##    namedodge aries se
##                -1.224e-01
##    namedodge aries wagon (sw)
##                -1.888e+00
##          namedodge aspen
##                1.331e+00
##          namedodge aspen 6
##                2.308e+00
##    namedodge aspen se
##                3.689e+00
##    namedodge challenger se
##                3.095e+00
##    namedodge charger 2.2
##                5.154e+00
##          namedodge colt
##                -1.898e-01
##    namedodge colt (sw)
##                1.580e+00
##    namedodge colt hardtop
##                -3.044e-01
##    namedodge colt hatchback custom
##                4.777e+00
##          namedodge colt m/m
##                4.757e+00
##    namedodge coronet brougham
##                1.094e+00
##    namedodge coronet custom
##                1.589e+00
##    namedodge coronet custom (sw)
##                5.698e-01
##    namedodge d100

```

```

##          -1.331e+00
##          namedodge d200
##          2.544e+00
##          namedodge dart custom
##          7.272e-01
##          namedodge diplomat
##          2.988e+00
##          namedodge magnum xe
##          1.376e+00
##          namedodge monaco (sw)
##          7.961e-01
##          namedodge monaco brougham
##          1.861e-01
##          namedodge omni
##          8.830e-01
##          namedodge rampage
##          3.491e-01
##          namedodge st. regis
##          2.127e+00
##          namefiat 124 sport coupe
##          -2.937e-01
##          namefiat 124 tc
##          -1.188e+00
##          namefiat 124b
##          3.040e+00
##          namefiat 128
##          -1.433e+00
##          namefiat 131
##          3.567e-01
##          namefiat strada custom
##          5.602e+00
##          namefiat x1.9
##          2.125e+00
##          nameford country
##          -3.034e-01
##          nameford country squire (sw)
##          5.448e-01
##          nameford escort 2h
##          7.595e-01
##          nameford escort 4w
##          2.674e+00
##          nameford f108
##          -1.695e+00
##          nameford f250
##          2.238e+00
##          nameford fairmont
##          1.821e-01
##          nameford fairmont (auto)
##          6.147e-02
##          nameford fairmont (man)
##          -1.481e+00
##          nameford fairmont 4
##          -3.784e+00
##          nameford fairmont futura

```

```

##          -4.210e+00
##      nameford fiesta
##          5.165e+00
##      nameford futura
##          4.231e-01
##      nameford galaxie 500
##          2.966e+00
##      nameford gran torino
##          1.057e+00
##      nameford gran torino (sw)
##          1.595e+00
##      nameford granada
##          3.153e+00
##      nameford granada ghia
##          3.530e+00
##      nameford granada gl
##          -8.437e-01
##      nameford granada l
##          1.172e+00
##      nameford ltd
##          2.055e-01
##      nameford ltd landau
##          1.603e-01
##      nameford maverick
##          3.700e+00
##      nameford mustang
##          3.198e+00
##      nameford mustang gl
##          -1.929e+00
##      nameford mustang ii
##          -2.868e+00
##      nameford mustang ii 2+2
##          -2.141e-01
##      nameford pinto
##          -1.329e+00
##      nameford pinto (sw)
##          -1.970e+00
##      nameford pinto runabout
##          -2.683e+00
##      nameford ranger
##          -8.544e-01
##      nameford thunderbird
##          1.468e+00
##      nameford torino
##          3.717e+00
##      nameford torino 500
##          4.773e+00
##      namehi 1200d
##          2.618e+00
##      namehonda accord
##          3.189e+00
##      namehonda accord cvcc
##          3.601e+00
##      namehonda accord lx

```



```

##                -8.450e-02
##                namehonda civic
##                2.386e+00
##                namehonda civic (auto)
##                -9.923e-01
##                namehonda civic 1300
##                1.955e+00
##                namehonda civic 1500 gl
##                1.170e+01
##                namehonda civic cvcc
##                5.089e+00
##                namehonda prelude
##                1.978e+00
##                namemaxda glc deluxe
##                2.179e+00
##                namemaxda rx3
##                -1.452e+01
##                namemazda 626
##                2.890e+00
##                namemazda glc
##                1.564e+01
##                namemazda glc 4
##                1.917e+00
##                namemazda glc custom
##                -8.571e-01
##                namemazda glc custom l
##                5.488e+00
##                namemazda glc deluxe
##                2.786e+00
##                namemazda rx-4
##                -1.170e+01
##                namemazda rx-7 gs
##                -1.312e+01
##                namemazda rx2 coupe
##                -1.262e+01
##                namemercedes-benz 240d
##                5.403e+00
##                namemercedes-benz 280s
##                -1.567e+00
##                namemercedes benz 300d
##                4.762e+00
##                namemercury capri 2000
##                -1.526e+00
##                namemercury capri v6
##                2.134e+00
##                namemercury cougar brougham
##                -3.463e-01
##                namemercury grand marquis
##                -4.431e-01
##                namemercury lynx l
##                4.528e+00
##                namemercury marquis
##                3.355e-01
##                namemercury marquis brougham

```

```

##                5.957e-01
##            namemercury monarch
##                8.645e-01
##        namemercury monarch ghia
##                3.443e+00
##            namemercury zephyr
##                1.179e+00
##        namemercury zephyr 6
##                4.466e-01
##        namenissan stanza xe
##                5.179e+00
##    nameoldsmobile cutlass ciera (diesel)
##                1.840e+01
##        nameoldsmobile cutlass ls
##                1.037e+01
##    nameoldsmobile cutlass salon brougham
##                6.443e+00
##        nameoldsmobile cutlass supreme
##                2.953e+00
##        nameoldsmobile delta 88 royale
##                3.358e-01
##        nameoldsmobile omega
##                -1.829e+00
##        nameoldsmobile omega brougham
##                4.730e+00
##        nameoldsmobile starfire sx
##                -9.067e-01
##        nameoldsmobile vista cruiser
##                3.324e-02
##            nameopel 1900
##                8.971e-01
##            nameopel manta
##                -1.891e+00
##            namepeugeot 304
##                5.048e+00
##            namepeugeot 504
##                2.108e-01
##        namepeugeot 504 (sw)
##                -1.050e+00
##        namepeugeot 505s turbo diesel
##                2.331e+00
##            namepeugeot 604sl
##                -3.189e+00
##        nameplymouth 'cuda 340
##                3.180e-01
##        nameplymouth arrow gs
##                -1.295e+00
##            nameplymouth champ
##                6.538e+00
##            nameplymouth cricket
##                2.430e+00
##        nameplymouth custom suburb
##                9.328e-01
##            nameplymouth duster

```

```

##          5.371e+00
##          nameplymouth fury
##          2.813e+00
##          nameplymouth fury gran sedan
##          1.739e+00
##          nameplymouth fury iii
##          2.754e+00
##          nameplymouth grand fury
##          2.550e+00
##          nameplymouth horizon
##          2.625e+00
##          nameplymouth horizon 4
##          2.611e+00
##          nameplymouth horizon miser
##          5.202e+00
##          nameplymouth horizon tc3
##          3.902e+00
##          nameplymouth reliant
##          -9.053e-01
##          nameplymouth sapporo
##          -8.213e-01
##          nameplymouth satellite
##          5.509e+00
##          nameplymouth satellite custom
##          1.611e+00
##          nameplymouth satellite custom (sw)
##          2.045e+00
##          nameplymouth satellite sebring
##          2.404e+00
##          nameplymouth valiant
##          3.683e+00
##          nameplymouth valiant custom
##          2.089e+00
##          nameplymouth volare
##          2.713e+00
##          nameplymouth volare custom
##          2.095e+00
##          nameplymouth volare premier v8
##          -1.791e+00
##          namepontiac astro
##          -4.508e-01
##          namepontiac catalina
##          3.072e+00
##          namepontiac catalina brougham
##          2.656e+00
##          namepontiac firebird
##          5.005e+00
##          namepontiac grand prix
##          4.701e+00
##          namepontiac grand prix lj
##          1.079e+00
##          namepontiac j2000 se hatchback
##          4.879e-01
##          namepontiac lemans v6

```

```

##                2.950e+00
##      namepontiac phoenix
##                3.125e+00
##      namepontiac phoenix lj
##                2.995e+00
##      namepontiac safari (sw)
##                1.944e+00
##      namepontiac sunbird coupe
##                -4.022e-01
##      namepontiac ventura sj
##                2.658e+00
##      namerenault 12 (sw)
##                6.930e-01
##      namerenault 12tl
##                -1.292e+00
##      namerenault 5 gtl
##                6.447e+00
##      namesaab 99e
##                2.258e+00
##      namesaab 99gle
##                -4.918e+00
##      namesaab 99le
##                -8.711e-01
##      namesubaru
##                7.138e-01
##      namesubaru dl
##                2.253e+00
##      nametoyota carina
##                -4.436e+00
##      nametoyota celica gt
##                2.796e+00
##      nametoyota celica gt liftback
##                -5.927e+00
##      nametoyota corolla
##                1.502e+00
##      nametoyota corolla 1200
##                5.190e+00
##      nametoyota corolla 1600 (sw)
##                1.721e+00
##      nametoyota corolla liftback
##                -1.835e+00
##      nametoyota corolla tercel
##                7.640e+00
##      nametoyota corona
##                -2.176e-04
##      nametoyota corona hardtop
##                -4.736e-01
##      nametoyota corona liftback
##                1.771e+00
##      nametoyota corona mark ii
##                4.271e-01
##      nametoyota cressida
##                1.834e+00
##      nametoyota mark ii

```

```

##          4.125e-01
##      nametoyota starlet
##          6.194e+00
##      nametoyota tercel
##          5.870e+00
##      nametoyota corona mark ii (sw)
##          -1.491e+00
##      nametriumph tr7 coupe
##          5.847e+00
##      namevolkswagen rabbit
##          -2.585e+00
##      namevolkswagen 1131 deluxe sedan
##          2.389e+00
##      namevolkswagen 411 (sw)
##          -1.321e+00
##      namevolkswagen dasher
##          -1.997e+00
##      namevolkswagen jetta
##          9.851e-01
##      namevolkswagen model 111
##          2.539e+00
##      namevolkswagen rabbit
##          -1.055e+00
##      namevolkswagen rabbit custom
##          -8.315e-01
##      namevolkswagen rabbit custom diesel
##          1.493e+01
##      namevolkswagen rabbit l
##          4.023e+00
##      namevolkswagen scirocco
##          4.628e-01
##      namevolkswagen super beetle
##          8.942e-01
##      namevolkswagen type 3
##          2.713e-01
##      namevolvo 144ea
##          -4.793e+00
##      namevolvo 145e (sw)
##          -5.774e+00
##      namevolvo 244dl
##          -4.162e+00
##      namevolvo 245
##          -5.288e+00
##      namevolvo 264gl
##          -3.999e+00
##      namevolvo diesel
##          8.598e+00
##      namevw dasher (diesel)
##          1.530e+01
##      namevw pickup
##          1.588e+01
##      namevw rabbit
##          4.377e+00
##      namevw rabbit c (diesel)

```

```
##              1.505e+01
##              namevw rabbit custom
##              -2.484e-01
##              cylinders:displacement
##              1.569e-02
```

Realmente es demasiado, no queremos un modelo tan complejo cuando uno mucho más general sirve (básicamente esto de utilizar los nombres de los carros es potencial para **overfit** en la fórmula). Vamos a reducir el modelo con una penalidad en la fórmula con el valor **k=5** que limite lo que estamos haciendo.

```
step(object = fit, direction = "backward", trace = 1, k=5)
```

```
## Start:  AIC=1585.27
## mpg ~ cylinders * displacement + horsepower + acceleration +
##       year + origin + name
##
##
## Step:  AIC=1585.27
## mpg ~ cylinders + displacement + horsepower + acceleration +
##       year + name + cylinders:displacement
##
##              Df Sum of Sq    RSS    AIC
## - name          300    3944.2 4389.9  981.99
## <none>                        445.6 1585.27
## - horsepower        1      11.5  457.1 1590.22
## - cylinders:displacement  1      55.1  500.8 1625.98
## - acceleration      1      60.9  506.6 1630.51
## - year              1     151.9  597.6 1695.27
##
## Step:  AIC=981.99
## mpg ~ cylinders + displacement + horsepower + acceleration +
##       year + cylinders:displacement
##
##              Df Sum of Sq    RSS    AIC
## <none>                        4389.9  981.99
## - acceleration      1     134.89 4524.8  988.86
## - horsepower        1     702.30 5092.2 1035.17
## - cylinders:displacement  1    1367.04 5756.9 1083.26
## - year              1     2136.94 6526.8 1132.47
##
##
## Call:
## lm(formula = mpg ~ cylinders + displacement + horsepower + acceleration +
##     year + cylinders:displacement, data = Auto)
##
## Coefficients:
##              (Intercept)              cylinders              displacement
##              10.34173              -3.76093              -0.14140
##              horsepower              acceleration              year
##              -0.09890              -0.30412              0.69946
## cylinders:displacement
##              0.01872
```

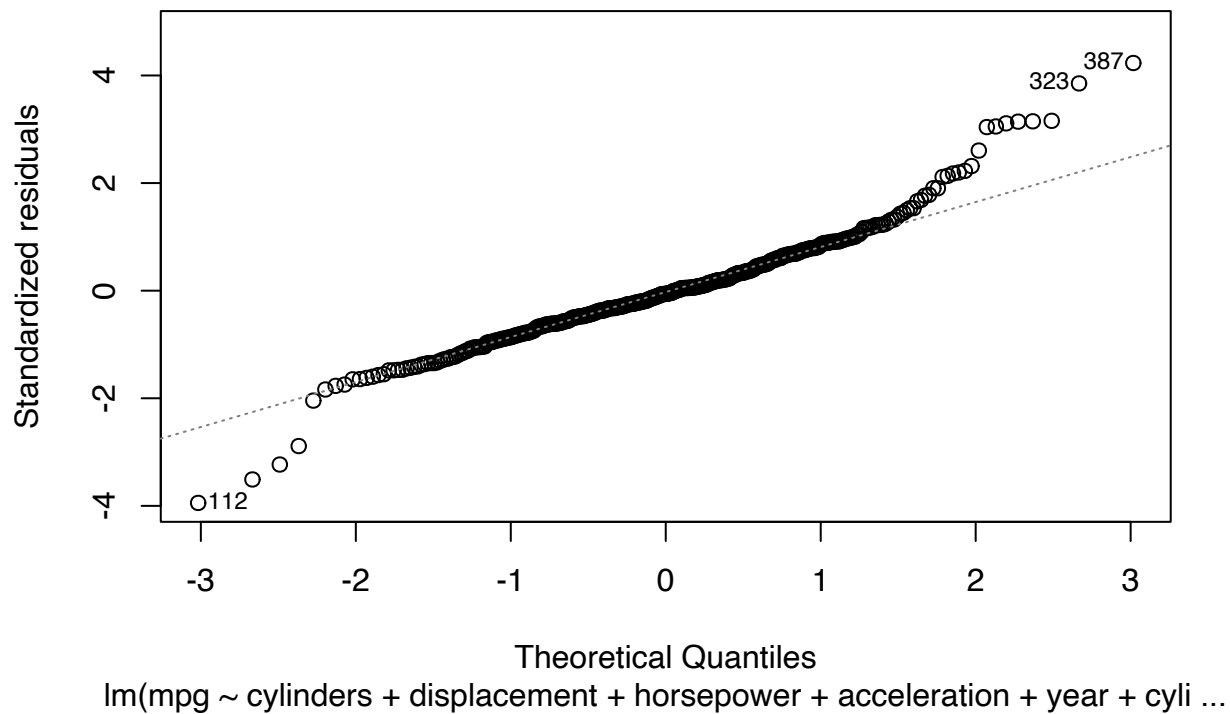
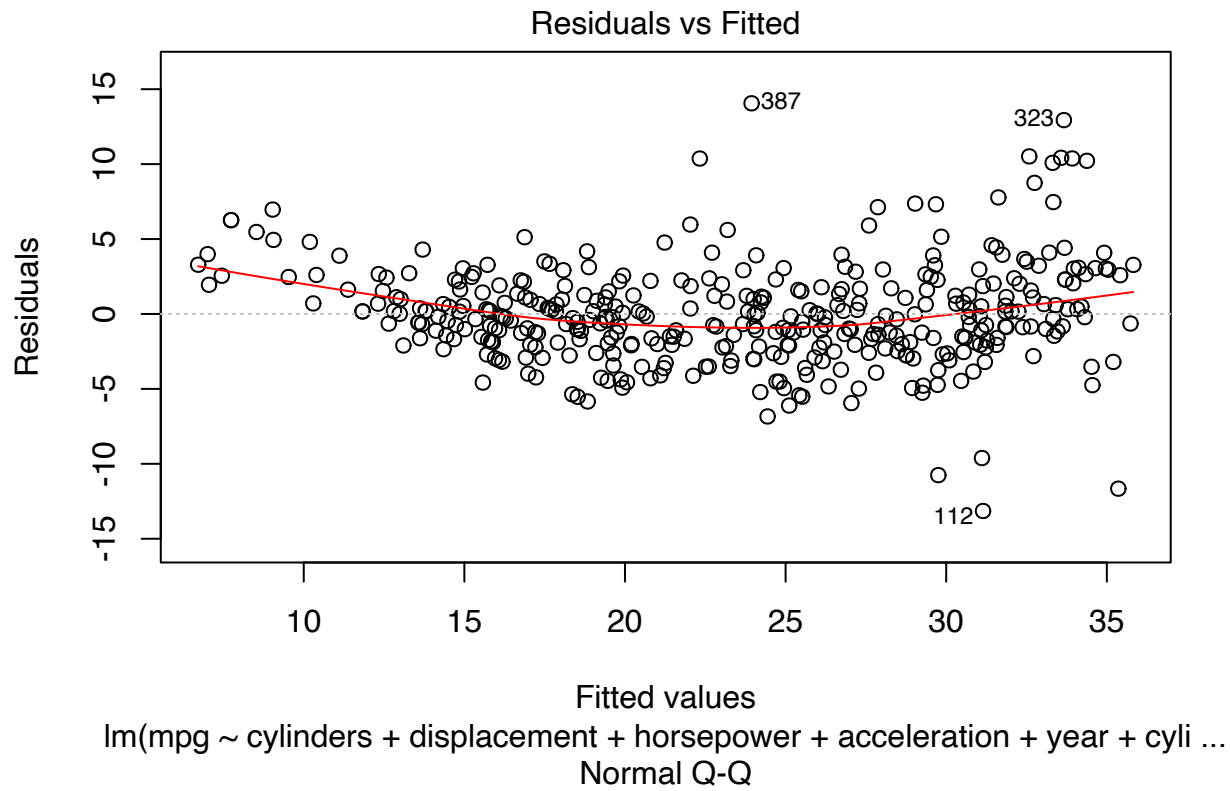
Podemos ver que el valor del AIC subió de 664,27 a 981,99 pero tenemos una fórmula más clara. Hagamos un gráfico para poder revisar nuestro ajuste de la regresión.

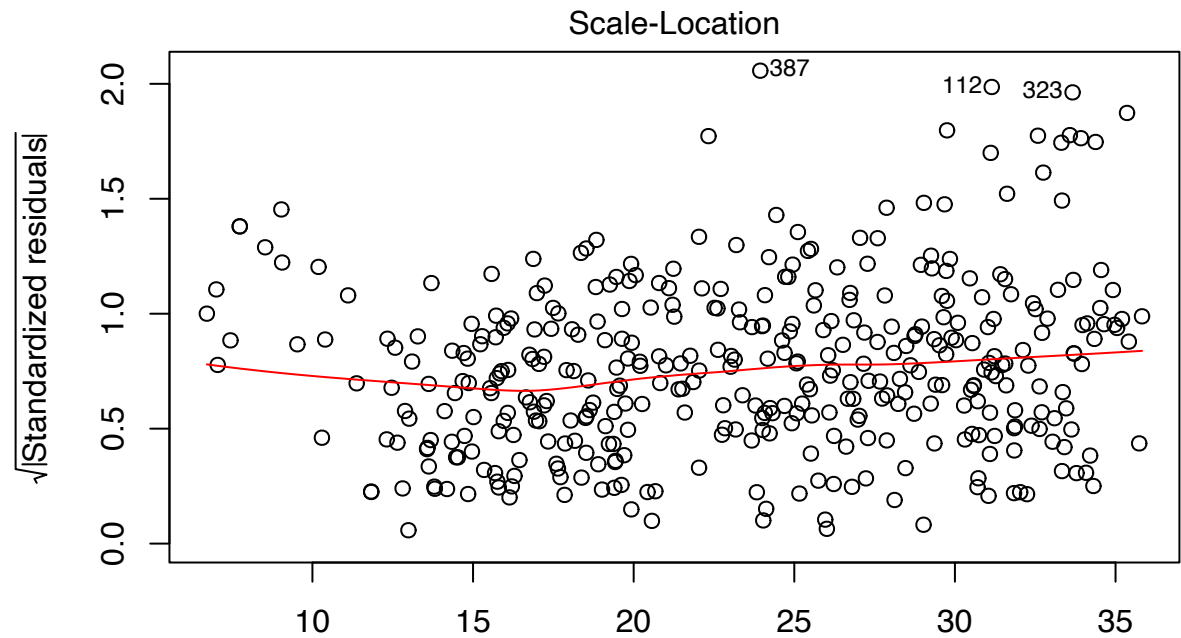
```
regresion <- step(object = fit, direction = "backward", k=5)

## Start: AIC=1585.27
## mpg ~ cylinders * displacement + horsepower + acceleration +
##       year + origin + name
##
##
## Step: AIC=1585.27
## mpg ~ cylinders + displacement + horsepower + acceleration +
##       year + name + cylinders:displacement
##
##              Df Sum of Sq    RSS    AIC
## - name          300      3944.2 4389.9  981.99
## <none>                        445.6 1585.27
## - horsepower        1        11.5  457.1 1590.22
## - cylinders:displacement  1        55.1  500.8 1625.98
## - acceleration      1        60.9  506.6 1630.51
## - year              1       151.9  597.6 1695.27
##
## Step: AIC=981.99
## mpg ~ cylinders + displacement + horsepower + acceleration +
##       year + cylinders:displacement
##
##              Df Sum of Sq    RSS    AIC
## <none>                        4389.9  981.99
## - acceleration      1       134.89 4524.8  988.86
## - horsepower        1       702.30 5092.2 1035.17
## - cylinders:displacement  1     1367.04 5756.9 1083.26
## - year              1     2136.94 6526.8 1132.47

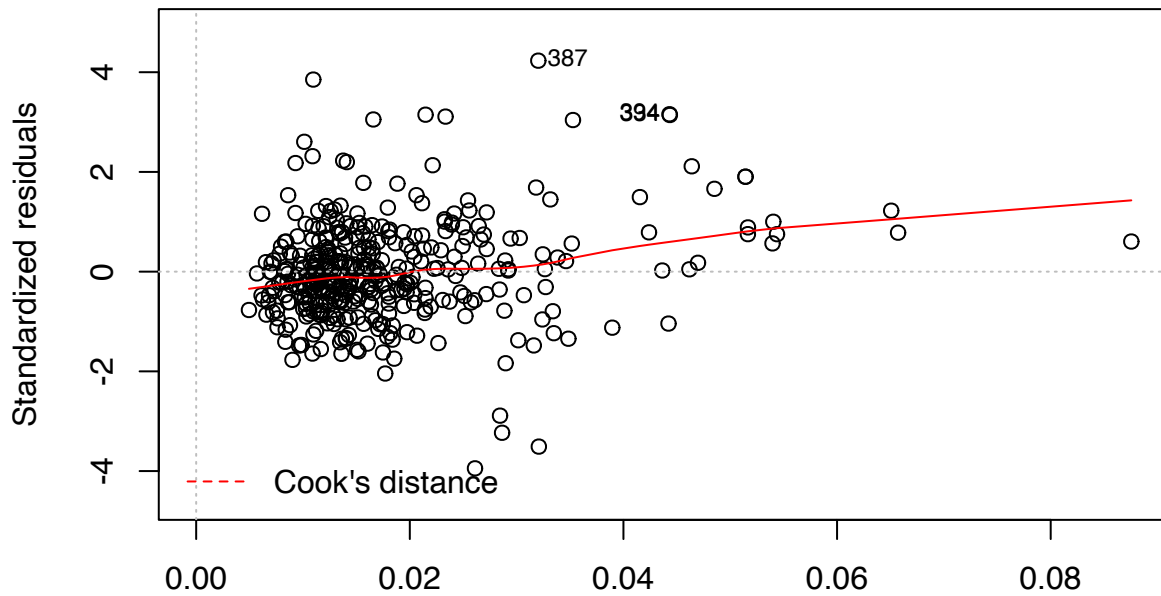
prediccion <- regresion$fitted.values
residuos <- regresion$residuals
cook <- cooks.distance(regresion)

plot(regresion)
```



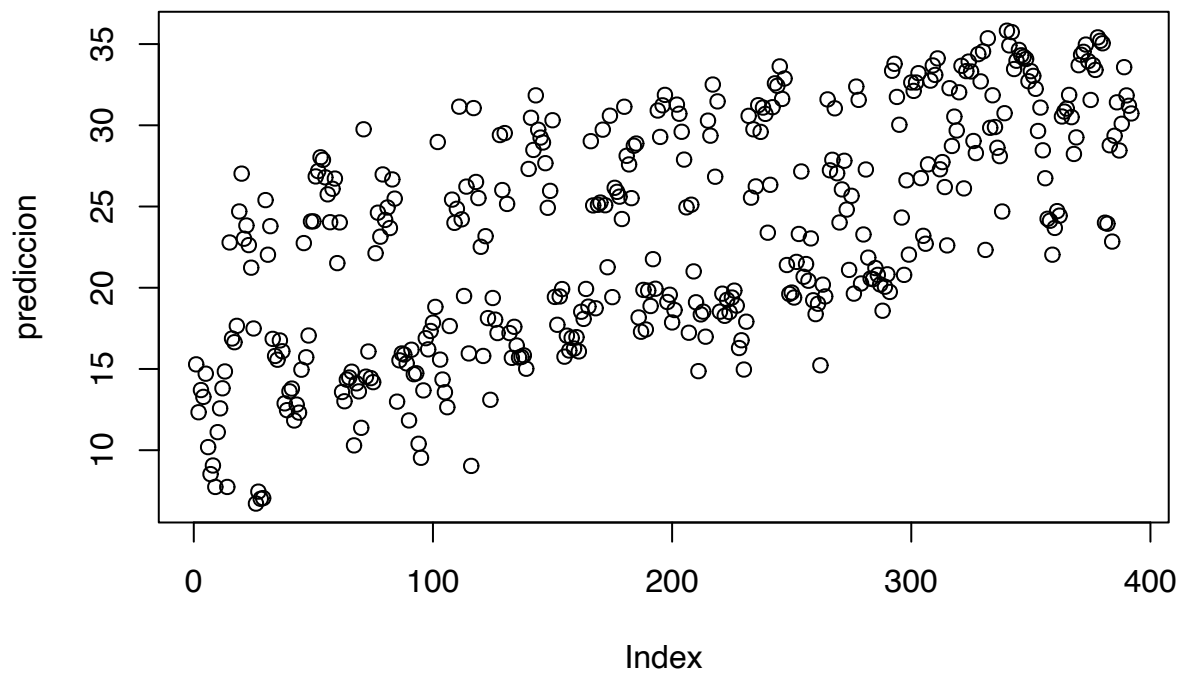


lm(mpg ~ cylinders + displacement + horsepower + acceleration + year + cyli ...
Residuals vs Leverage

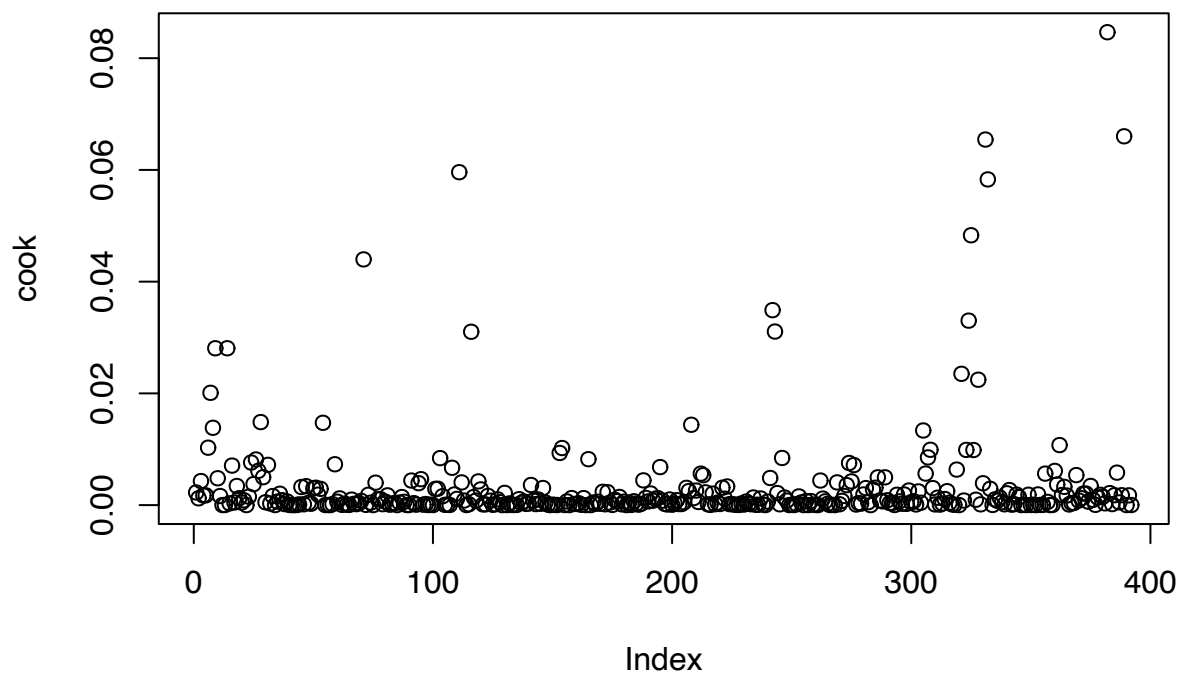


Leverage
lm(mpg ~ cylinders + displacement + horsepower + acceleration + year + cyli ...

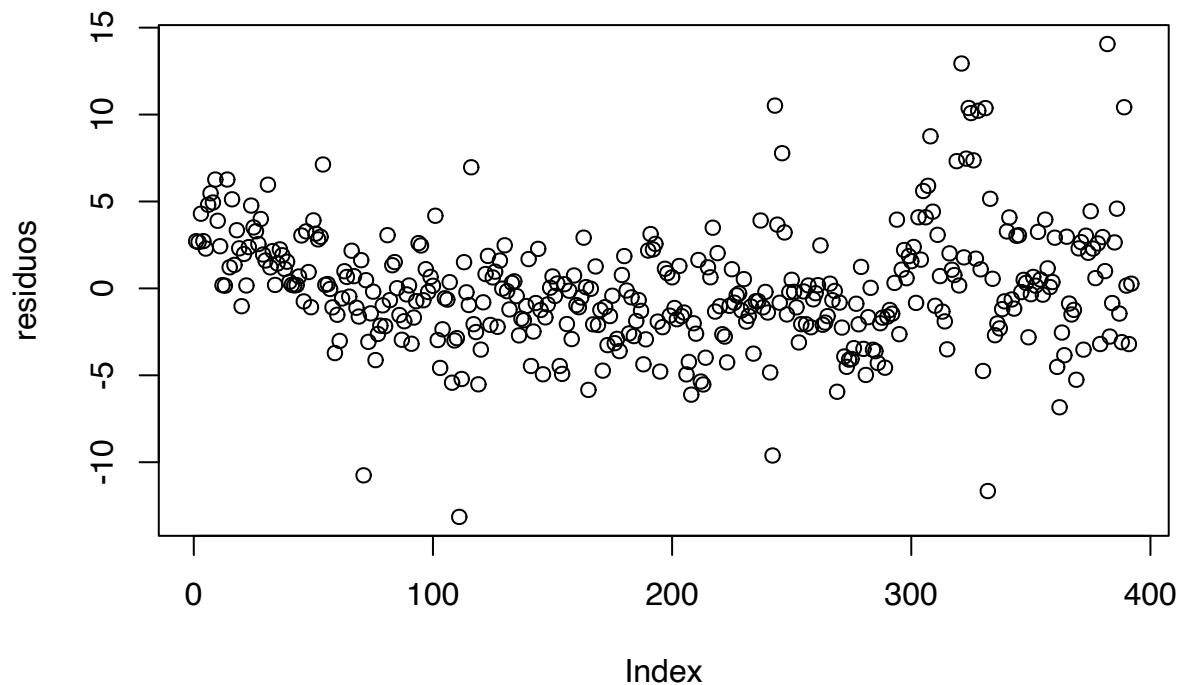
```
plot(prediccion)
```



```
plot(cook)
```



```
plot(residuos)
```



Por último revisemos la homocedasticidad de los residuos y que no tengamos heterocedasticidad.

```
library(lmtest)
```

```
## Warning: package 'lmtest' was built under R version 3.6.2
```

```
## Loading required package: zoo
```

```
## Warning: package 'zoo' was built under R version 3.6.2
```

```
##
```

```
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
```

```
##
```

```
## as.Date, as.Date.numeric
```

```
bptest(regresion)
```

```
##
```

```
## studentized Breusch-Pagan test
```

```
##
```

```
## data: regresion
```

```
## BP = 25.966, df = 6, p-value = 0.0002259
```

```
shapiro.test(residuos)
```

```
##
```

```
## Shapiro-Wilk normality test
```

```
##
```

```
## data: residuos
```

```
## W = 0.95797, p-value = 3.786e-09
```