

Estadística básica con R

Oscar Perpiñán Lamigueiro

<http://oscarperpinan.github.io>

Conjunto de datos

Estadística
Univariante

Generar datos
aleatorios

Tests de Hipótesis

Regresión lineal

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Conjunto de datos: swiss

Standardized fertility measure and socio-economic indicators for each of 47 French-speaking provinces of Switzerland at about 1888. 6 variables in percent [0, 100]:

- ▶ **Fertility**: Ig, 'common standardized fertility measure'
- ▶ **Agriculture**: % of males involved in agriculture as occupation
- ▶ **Examination**: % draftees receiving highest mark on army examination
- ▶ **Education**: % education beyond primary school for draftees.
- ▶ **Catholic**: % 'catholic' (as opposed to 'protestant').
- ▶ **Infant.Mortality**: live births who live less than 1year.

Conjunto de datos: swiss

```
data(swiss)
```

```
summary(swiss)
```

Fertility	Agriculture	Examination	Education
Min. :35.00	Min. : 1.20	Min. : 3.00	Min. : 1.00
1st Qu.:64.70	1st Qu.:35.90	1st Qu.:12.00	1st Qu.: 6.00
Median :70.40	Median :54.10	Median :16.00	Median : 8.00
Mean :70.14	Mean :50.66	Mean :16.49	Mean :10.98
3rd Qu.:78.45	3rd Qu.:67.65	3rd Qu.:22.00	3rd Qu.:12.00
Max. :92.50	Max. :89.70	Max. :37.00	Max. :53.00

Catholic	Infant.Mortality
Min. : 2.150	Min. :10.80
1st Qu.: 5.195	1st Qu.:18.15
Median :15.140	Median :20.00
Mean : 41.144	Mean :19.94
3rd Qu.: 93.125	3rd Qu.:21.70
Max. :100.000	Max. :26.60

Conjunto de datos

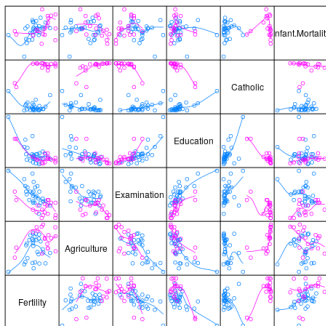
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```
library(lattice)  
splom(swiss, pscale=0, type=c('p', 'smooth'),  
      groups=swiss$Catholic > 50, xlab='')
```



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Resumen de información

```
summary(swiss)
```

```
      Fertility      Agriculture      Examination      Education
Min.   :35.00    Min.   : 1.20    Min.   : 3.00    Min.   : 1.00
1st Qu.:64.70    1st Qu.:35.90    1st Qu.:12.00   1st Qu.: 6.00
Median :70.40    Median :54.10    Median :16.00   Median : 8.00
Mean   :70.14    Mean   :50.66    Mean   :16.49   Mean   :10.98
3rd Qu.:78.45    3rd Qu.:67.65    3rd Qu.:22.00   3rd Qu.:12.00
Max.   :92.50    Max.   :89.70    Max.   :37.00   Max.   :53.00

      Catholic      Infant.Mortality
Min.   : 2.150    Min.   :10.80
1st Qu.: 5.195    1st Qu.:18.15
Median :15.140    Median :20.00
Mean   :41.144    Mean   :19.94
3rd Qu.:93.125    3rd Qu.:21.70
Max.   :100.000   Max.   :26.60
```

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```
mean(swiss$Fertility)
```

```
[1] 70.14255
```

```
colMeans(swiss)
```

Fertility	Agriculture	Examination	Education
70.14255	50.65957	16.48936	10.97872
Catholic	Infant.Mortality		
41.14383	19.94255		

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Desviación Estándar

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```
sd(swiss$Fertility)
```

```
[1] 12.4917
```

```
sapply(swiss, sd)
```

Fertility	Agriculture	Examination	Education
12.491697	22.711218	7.977883	9.615407
Catholic	Infant.Mortality		
41.704850	2.912697		

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```
median(swiss$Fertility)
```

```
[1] 70.4
```

```
mad(swiss$Fertility)
```

```
[1] 10.22994
```

```
IQR(swiss$Fertility)
```

```
[1] 13.75
```

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Distribuciones disponibles

- ▶ beta beta
- ▶ binomial binom
- ▶ Cauchy cauchy
- ▶ chi-squared chisq
- ▶ exponential exp
- ▶ F f
- ▶ gamma gamma
- ▶ geometric geom
- ▶ hypergeometric hyper
- ▶ log-normal lnorm
- ▶ logistic logis
- ▶ negative binomial
- ▶ normal norm
- ▶ Poisson pois
- ▶ signed rank signrank
- ▶ Student's t t
- ▶ uniform unif
- ▶ Weibull weibull
- ▶ Wilcoxon wilcox

Densidad, CDF, Cuantiles, y Números aleatorios

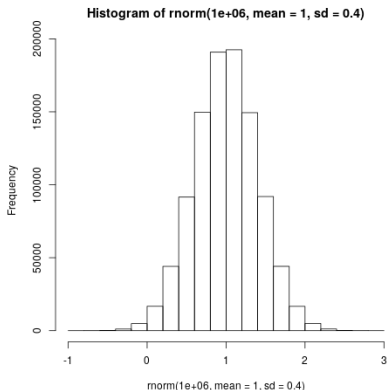
- `dxxx` función de densidad de probabilidad
- `pxxx` función acumulada de probabilidad
- `qxxx` cuantiles
- `rxxx` generación de números aleatorios

Distribución Normal

```
rnorm(10, mean = 1, sd = .4)
```

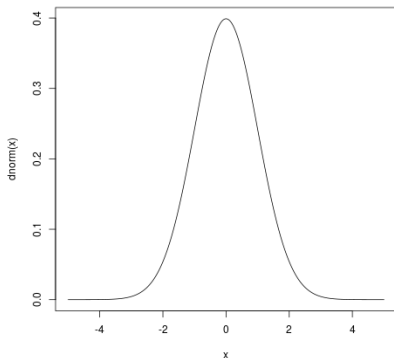
```
[1] 1.1074734 0.9546605 1.6954057 1.4686564 1.2811518 0.5590597 0.7941302  
[8] 1.0103583 0.4762850 1.3571223
```

```
hist(rnorm(1e6, mean = 1, sd = .4))
```



Distribución Normal

```
x <- seq( -5, 5, by =.01)  
plot(x, dnorm(x), type = 'l')
```

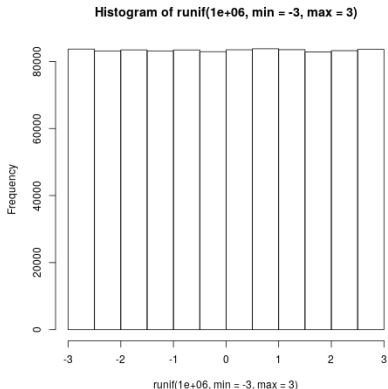


Distribución Uniforme

```
runif(10, min=-3, max=3)
```

```
[1] 2.80044210 1.93678185 2.02776507 0.08118988 0.24301041 0.62181219  
[7] 0.57250231 -2.28872042 -2.22046950 -1.75565844
```

```
hist(runif(1e6, min = -3, max = 3))
```

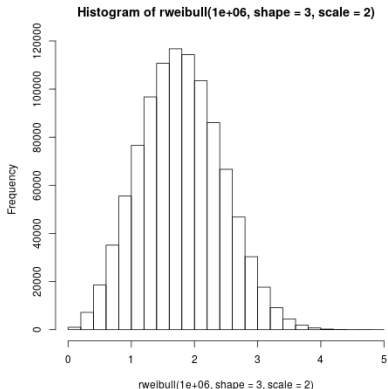


Distribución de Weibull

```
rweibull(n=10, shape = 3, scale = 2)
```

```
[1] 1.8779252 1.8438342 1.4712878 1.6678865 2.2109469 2.2213818 1.7035614  
[8] 0.9951536 1.1239665 2.0436414
```

```
hist(rweibull(1e6, shape = 3, scale = 2))
```



Muestreo aleatorio

```
x <- seq(1, 100, length = 10)
```

```
x
```

```
[1] 1 12 23 34 45 56 67 78 89 100
```

► Sin reemplazo

```
sample(x)
```

```
[1] 1 100 34 23 67 78 56 45 89 12
```

```
sample(x, 5)
```

```
[1] 12 67 34 100 45
```

► Con reemplazo

```
sample(x, 5, replace = TRUE)
```

```
[1] 23 67 89 34 100
```

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Para muestra única

► t de Student

```
t.test(swiss$Fertility, mu=70)
```

One Sample t-test

```
data: swiss$Fertility
t = 0.078236, df = 46, p-value = 0.938
alternative hypothesis: true mean is not equal to 70
95 percent confidence interval:
 66.47485 73.81025
sample estimates:
mean of x
 70.14255
```

► Wilcoxon (no paramétrico)

```
wilcox.test(swiss$Fertility, mu=70)
```

Wilcoxon signed rank test with continuity correction

```
data: swiss$Fertility
V = 592.5, p-value = 0.767
alternative hypothesis: true location is not equal to 70

Warning message:
In wilcox.test.default(swiss$Fertility, mu = 70) :
  cannot compute exact p-value with ties
```

Para muestras pareadas

```
Religion <- ifelse(swiss$Catholic > 50,  
                  'Catholic', 'Protestant')
```

► t de Student

```
t.test(Fertility ~ Religion, data=swiss)
```

```
Welch Two Sample t-test
```

```
data: Fertility by Religion  
t = 2.7004, df = 26.742, p-value = 0.01186  
alternative hypothesis: true difference in means is not equal to 0  
95 percent confidence interval:  
 2.455904 18.024939  
sample estimates:  
 mean in group Catholic mean in group Protestant  
    76.46111             66.22069
```

► Wilcoxon

```
wilcox.test(Fertility ~ Religion, data=swiss)
```

```
Wilcoxon rank sum test with continuity correction
```

```
data: Fertility by Religion
```

```
W = 409.5, p-value = 0.0012
```

```
alternative hypothesis: true location shift is not equal to 0
```

```
Warning message:
```

```
In wilcox.test.default(x = c(83.1, 92.5, 76.1, 83.8, 92.4, 82.4, ...):  
cannot compute exact p-value with ties
```

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Fertilidad y educación

```
lmFertEdu <- lm(Fertility ~ Education,  
               data = swiss)  
summary(lmFertEdu)
```

```
Call:  
lm(formula = Fertility ~ Education, data = swiss)  
  
Residuals:  
    Min       1Q   Median       3Q      Max  
-17.036  -6.711  -1.011    9.526  19.689  
  
Coefficients:  
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  79.6101     2.1041  37.836 < 2e-16 ***  
Education    -0.8624     0.1448  -5.954 3.66e-07 ***  
---  
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
  
Residual standard error: 9.446 on 45 degrees of freedom  
Multiple R-squared:  0.4406,    Adjusted R-squared:  0.4282  
F-statistic: 35.45 on 1 and 45 DF,  p-value: 3.659e-07
```

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Fertilidad y educación

```
coef(lmFertEdu)
```

```
(Intercept) Education  
79.6100585 -0.8623503
```

```
fitted.values(lmFertEdu)
```

Courtelayr	Delemont	Franches-Mnt	Moutier	Neuveville	Porrentruy
69.26186	71.84891	75.29831	73.57361	66.67480	73.57361
Broye	Glane	Gruyere	Sarine	Veveyse	Aigle
73.57361	72.71126	73.57361	68.39950	74.43596	69.26186
Aubonne	Avenches	Cossonay	Echallens	Grandson	Lausanne
73.57361	69.26186	75.29831	77.88536	72.71126	55.46425
La Vallee	Lavaux	Morges	Moudon	Nyone	Orbe
62.36305	71.84891	70.98656	77.02301	69.26186	74.43596
Oron	Payerne	Paysd'enhaut	Rolle	Vevey	Yverdon
78.74771	72.71126	77.02301	70.98656	63.22540	72.71126
Conthey	Entremont	Herens	Martigny	Monthey	St Maurice
77.88536	74.43596	77.88536	74.43596	77.02301	71.84891
Sierre	Sion	Boudry	La Chauxdfnd	Le Locle	Neuchatel
77.02301	68.39950	69.26186	70.12421	68.39950	52.01485
Val de Ruz	ValdeTravers	V. De Geneve	Rive Droite	Rive Gauche	
73.57361	73.57361	33.90549	54.60190	54.60190	

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```
residuals(lmFertEdu)
```

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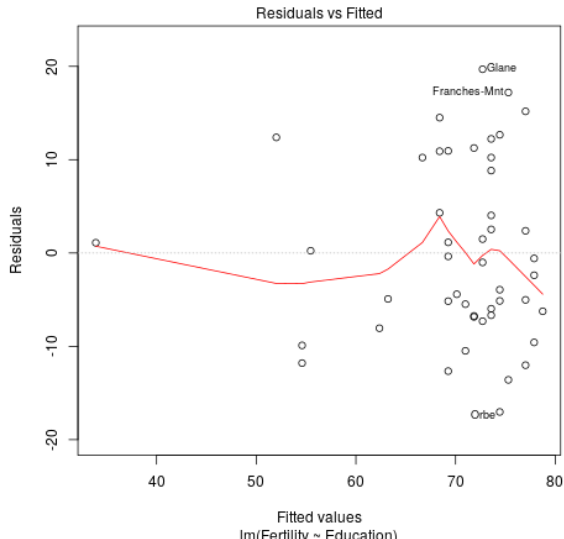
Tests de Hipótesis

Regresión lineal

```
Courtelay      Delemont Franches-Mnt      Moutier      Neuveville      Porrentruy
10.9381450      11.2510941      17.2016929      12.2263935      10.2251959      2.5263935
  Broye          Glane          Gruyere          Sarine          Veveyse          Aigle
10.2263935      19.6887438      8.8263935      14.5004953      12.6640432      -5.1618550
  Aubonne        Avenches        Cossonay        Echallens        Grandson        Lausanne
-6.6736065      -0.3618550      -13.5983071      -9.5853579      -1.0112562      0.2357497
  La Vallee      Lavaux          Morges          Moudon          Nyone            Orbe
-8.0630527      -6.7489059      -5.4865556      -12.0230077      -12.6618550      -17.0359568
  Oron           Payerne        Pays'd'enhaut      Rolle          Vevey            Yverdon
-6.2477082      1.4887438      -5.0230077      -10.4865556      -4.9254030      -7.3112562
  Conthey        Entremont        Herens          Martigwy        Monthey        St Maurice
-2.3853579      -5.1359568      -0.5853579      -3.9359568      2.3769923      -6.8489059
  Sierre         Sion            Boudry          La Chauxdfnd      Le Locle        Neuchatel
15.1769923      10.9004953      1.1381450      -4.4242053      4.3004953      12.3851508
Val de Ruz      ValdeTravers    V. De Geneve      Rive Droite      Rive Gauche
4.0263935      -5.9736065      1.0945070      -9.9019000      -11.8019000
```

Fertilidad y educación

```
plot(lmFertEdu, which = 1)
```



Fertilidad, educación y religión

```
lmFertEduCat <- lm(Fertility ~ Education + Catholic,  
                   data = swiss)  
summary(lmFertEduCat)
```

```
Call:  
lm(formula = Fertility ~ Education + Catholic, data = swiss)  
  
Residuals:  
    Min       1Q   Median       3Q      Max  
-15.042  -6.578  -1.431    6.122   14.322  
  
Coefficients:  
            Estimate Std. Error t value Pr(>|t|)  
(Intercept) 74.23369    2.35197   31.562 < 2e-16 ***  
Education   -0.78833    0.12929   -6.097 2.43e-07 ***  
Catholic     0.11092    0.02981    3.721 0.00056 ***  
---  
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
  
Residual standard error: 8.331 on 44 degrees of freedom  
Multiple R-squared:  0.5745,    Adjusted R-squared:  0.5552  
F-statistic: 29.7 on 2 and 44 DF,  p-value: 6.849e-09
```

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Lo mismo con update

```
lmFertEduCat <- update(lmFertEdu, . ~ . + Catholic,
                        data = swiss)
summary(lmFertEduCat)
```

```
Call:
lm(formula = Fertility ~ Education + Catholic, data = swiss)

Residuals:
    Min       1Q   Median       3Q      Max
-15.042  -6.578  -1.431   6.122  14.322

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  74.23369    2.35197  31.562 < 2e-16 ***
Education   -0.78833    0.12929  -6.097 2.43e-07 ***
Catholic     0.11092    0.02981   3.721 0.00056 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 8.331 on 44 degrees of freedom
Multiple R-squared:  0.5745,    Adjusted R-squared:  0.5552
F-statistic: 29.7 on 2 and 44 DF,  p-value: 6.849e-09
```

Fertilidad, educación, religión y agricultura

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```
lmFertEduCatAgr <- lm(Fertility ~ Education +  
  Catholic + Agriculture,  
                      data = swiss)  
summary(lmFertEduCatAgr)
```

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Regresión lineal

```
Call:  
lm(formula = Fertility ~ Education + Catholic + Agriculture,  
    data = swiss)  
  
Residuals:  
    Min       1Q   Median       3Q      Max  
-15.178  -6.548   1.379   5.822  14.840  
  
Coefficients:  
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  86.22502    4.73472  18.211 < 2e-16 ***  
Education    -1.07215    0.15580  -6.881 1.91e-08 ***  
Catholic      0.14520    0.03015   4.817 1.84e-05 ***  
Agriculture  -0.20304    0.07115  -2.854 0.00662 **  
---  
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
  
Residual standard error: 7.728 on 43 degrees of freedom  
Multiple R-squared:  0.6423,    Adjusted R-squared:  0.6173  
F-statistic: 25.73 on 3 and 43 DF,  p-value: 1.089e-09
```

Lo mismo con update

```
lmFertEduCatAgr <- update(lmFertEduCat,  
                          . ~ . + Agriculture,  
                          data = swiss)  
  
summary(lmFertEduCatAgr)
```

```
Call:  
lm(formula = Fertility ~ Education + Catholic + Agriculture,  
    data = swiss)  
  
Residuals:  
    Min      1Q  Median      3Q     Max  
-15.178  -6.548   1.379   5.822  14.840  
  
Coefficients:  
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  86.22502   4.73472  18.211 < 2e-16 ***  
Education    -1.07215   0.15580  -6.881 1.91e-08 ***  
Catholic      0.14520   0.03015   4.817 1.84e-05 ***  
Agriculture  -0.20304   0.07115  -2.854 0.00662 **  
---  
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
  
Residual standard error: 7.728 on 43 degrees of freedom  
Multiple R-squared:  0.6423,    Adjusted R-squared:  0.6173  
F-statistic: 25.73 on 3 and 43 DF,  p-value: 1.089e-09
```

Lo mismo con update

```
lmFertEduCatAgr <- update(lmFertEdu,  
                          . ~ . + Catholic + Agriculture,  
                          data = swiss)  
summary(lmFertEduCatAgr)
```

```
Call:  
lm(formula = Fertility ~ Education + Catholic + Agriculture,  
    data = swiss)  
  
Residuals:  
    Min       1Q   Median       3Q      Max  
-15.178  -6.548   1.379   5.822  14.840  
  
Coefficients:  
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  86.22502   4.73472  18.211 < 2e-16 ***  
Education    -1.07215   0.15580  -6.881 1.91e-08 ***  
Catholic      0.14520   0.03015   4.817 1.84e-05 ***  
Agriculture  -0.20304   0.07115  -2.854 0.00662 **  
---  
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
  
Residual standard error: 7.728 on 43 degrees of freedom  
Multiple R-squared:  0.6423,    Adjusted R-squared:  0.6173  
F-statistic: 25.73 on 3 and 43 DF,  p-value: 1.089e-09
```


Comparamos modelos con anova

```
anova(lmFertEdu, lmFertEduCat, lmFertEduCatAgr)
```

Analysis of Variance Table

Model 1: Fertility ~ Education

Model 2: Fertility ~ Education + Catholic

Model 3: Fertility ~ Education + Catholic + Agriculture

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)	
1	45	4015.2					
2	44	3054.2	1	961.07	16.093	0.0002365	***
3	43	2567.9	1	486.28	8.143	0.0066235	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Fertilidad contra todo

```
lmFert <- lm(Fertility ~ ., data=swiss)
```

```
summary(lmFert)
```

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

Residuals:
    Min       1Q   Median       3Q      Max
-15.2743  -5.2617   0.5032   4.1198  15.3213

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  66.91518    10.70604   6.250 1.91e-07 ***
Agriculture  -0.17211     0.07030  -2.448 0.01873 *
Examination  -0.25801     0.25388  -1.016 0.31546
Education    -0.87094     0.18303  -4.758 2.43e-05 ***
Catholic      0.10412     0.03526   2.953 0.00519 **
Infant.Mortality 1.07705     0.38172   2.822 0.00734 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.165 on 41 degrees of freedom
Multiple R-squared:  0.7067,    Adjusted R-squared:  0.671
F-statistic: 19.76 on 5 and 41 DF,  p-value: 5.594e-10
```

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Elegir un modelo con anova

```
anova(lmFert)
```

```
Analysis of Variance Table
```

```
Response: Fertility
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Agriculture	1	894.84	894.84	17.4288	0.0001515	***
Examination	1	2210.38	2210.38	43.0516	6.885e-08	***
Education	1	891.81	891.81	17.3699	0.0001549	***
Catholic	1	667.13	667.13	12.9937	0.0008387	***
Infant.Mortality	1	408.75	408.75	7.9612	0.0073357	**
Residuals	41	2105.04	51.34			

```
---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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Elegir un modelo con step

```
stepFert <- step(lmFert)
```

Start: AIC=190.69

```
Fertility ~ Agriculture + Examination + Education + Catholic +  
Infant.Mortality
```

	Df	Sum of Sq	RSS	AIC
- Examination	1	53.03	2158.1	189.86
<none>			2105.0	190.69
- Agriculture	1	307.72	2412.8	195.10
- Infant.Mortality	1	408.75	2513.8	197.03
- Catholic	1	447.71	2552.8	197.75
- Education	1	1162.56	3267.6	209.36

Step: AIC=189.86

```
Fertility ~ Agriculture + Education + Catholic + Infant.Mortality
```

	Df	Sum of Sq	RSS	AIC
<none>			2158.1	189.86
- Agriculture	1	264.18	2422.2	193.29
- Infant.Mortality	1	409.81	2567.9	196.03
- Catholic	1	956.57	3114.6	205.10
- Education	1	2249.97	4408.0	221.43

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summary(stepFert)

```
Call:
lm(formula = Fertility ~ Agriculture + Education + Catholic +
    Infant.Mortality, data = swiss)

Residuals:
    Min       1Q   Median       3Q      Max
-14.6765  -6.0522   0.7514   3.1664  16.1422

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  62.10131    9.60489   6.466 8.49e-08 ***
Agriculture  -0.15462    0.06819  -2.267 0.02857 *
Education    -0.98026    0.14814  -6.617 5.14e-08 ***
Catholic      0.12467    0.02889   4.315 9.50e-05 ***
Infant.Mortality 1.07844    0.38187   2.824 0.00722 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.168 on 42 degrees of freedom
Multiple R-squared:  0.6993,    Adjusted R-squared:  0.6707
F-statistic: 24.42 on 4 and 42 DF,  p-value: 1.717e-10
```

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Elegir un modelo

Estadística básica
con R

Oscar Perpiñán
Lamigueiro
[http://
oscarperpinan.
github.io](http://oscarperpinan.github.io)

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```
stepFert$anova
```

	Step	Df	Deviance	Resid. Df	Resid. Dev	AIC
1		NA	NA	41	2105.043	190.6913
2 - Examination	1	53.02656		42	2158.069	189.8606