

ROTINAMONO1.1.R

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```
##### Heterocedasticidade
```

```
# Limpar memoria
```

```
rm(list=ls())
```

```
# Selecionar diretorio
```

```
setwd("/Users/nicholaslepetit/Documents/ECONOMIA/01.2019/Econometria I/Parte 3")
```

```
dir()
```

```
## [1] "br2.csv" "cps4_small.csv"
## [3] "food.csv" "monograph1.png"
## [5] "p3_15024623.pages" "p3_15024623.pdf"
## [7] "phone.csv" "relatoriomono_pdf.pdf"
## [9] "relatoriomono.pages" "revisao.R"
## [11] "rotina90.R" "rotina91.R"
## [13] "rotina92.R" "rotina93 c dica.R"
## [15] "ROTINAMONO.R" "ROTINAMONO1.1.html"
## [17] "ROTINAMONO1.1.R" "rotinap3_15024623.R"
## [19] "utown.csv"
```

```
phones <- read.csv("phone.csv")
```

```
## Warning in scan(file = file, what = what, sep = sep, quote = quote, dec =
```

```
## dec, : EOF within quoted string
```

```
# Extraindo os numeros referentes a capacidade da bateria espalhados pela coluna "battery" das observacoes
```

```
mAh <- gsub("[^0-9.]", "", phones$battery)
```

```
head(mAh,1000)
```

```
## [1] "340012.92" "4080" "2000" "" "4020"
## [6] "" "5000" "2000" "4420" "2870"
## [11] "2000" "2000" "400015.2" "4000" "2420"
## [16] "2420" "2000" "2000" "591022" "455017.2"
## [21] "59103201" "59103208" "2300" "2000" "1300"
## [26] "1300" "2000" "2300" "2000" "2700"
## [31] "2100" "3500" "2500" "1300" "4600"
## [36] "" "" "3700" "" ""
## [41] "1630" "2955" "2955" "4000" "2000"
## [46] "3300" "1500" "2400" "730027" "496018.6"
## [51] "496018.6" "2000" "1300" "2000" "1760"
## [56] "2640" "271010" "342012.7" "1300" "1500"
## [61] "1500" "1300" "1460" "3260" "3260"
## [66] "980036" "9800" "980036" "980036" "1300"
## [71] "" "326024.1" "1500" "3260" "1530"
## [76] "1530" "1300" "1300" "1300" "1500"
## [81] "1500" "1500" "1500" "1400" "1350"
## [86] "1090" "1090" "970" "1500" "1350"
## [91] "1350" "1140" "1140" "1140" "1260"
## [96] "1530" "1530" "1530" "1530" "3100"
## [101] "2050" "2800" "2460" "3000" "2460"
## [106] "5000" "2500" "5000" "3480" "468018"
## [111] "2600" "4100" "3000" "7800" "341"
## [116] "590022" "4130" "3000" "2600" "4100"
## [121] "4680" "4600" "3000" "3000" "5000"
## [126] "2070" "2070" "3010" "2500" "1600"
## [131] "2070" "400" "300" "1.4" "3000"
## [136] "3000" "400015.2" "18" "18" "2070"
## [141] "5000" "3000" "3000" "3000" "3000"
## [146] "" "2400" "13" "2500" "3030"
## [151] "15.2" "15.2" "400015.2" "15.2" "13"
## [156] "13" "3000" "2500" "3000" "3000"
## [161] "15" "2100" "15" "3000" "2500"
## [166] "2500" "19" "2060" "15" "15"
```

##	[171]	"2110"	"1750"	"15.2"	"15.2"	"15"
##	[176]	"15.2"	"15"	"15"	"25"	"19"
##	[181]	"15"	"2300"	"2300"	"2400"	"1820"
##	[186]	"3230"	"330012"	"2110"	"2110"	"12001600"
##	[191]	"2060"	"1170"	"1500"	"19"	"2400"
##	[196]	"5070"	"3950"	"395015"	"	"
##	[201]	"320015"	"31"	"676025"	"15"	"15"
##	[206]	"427016"	"2400"	"19"	"427016"	"432516"
##	[211]	"25"	"2140"	"432516"	"25"	"25"
##	[216]	"22"	"22"	"25"	"4400"	"25"
##	[221]	"25"	"1520"	"1100"	"24.4"	"1300"
##	[226]	"1300"	"1100"	"1100"	"1100"	"1530"
##	[231]	"1300"	"	"750"	"	"
##	[236]	"1200"	"1300"	"750"	"1300"	"720"
##	[241]	"1300"	"1300"	"1000"	"700"	"700"
##	[246]	"920"	"750"	"720"	"720"	"700"
##	[251]	"5000"	"3000"	"2200"	"2200"	"2300"
##	[256]	"3000"	"3000"	"4000"	"2200"	"4000"
##	[261]	"2500"	"2500"	"2500"	"3000"	"1800"
##	[266]	"1700"	"5000"	"2800"	"2500"	"1400"
##	[271]	"3000"	"2800"	"2000"	"2000"	"3000"
##	[276]	"1300"	"2000"	"2000"	"1800"	"2300"
##	[281]	"3200"	"2450"	"2750"	"4000"	"2820"
##	[286]	"2500"	"4000"	"2500"	"2000"	"2000"
##	[291]	"2000"	"3150"	"3150"	"2900"	"2800"
##	[296]	"2500"	"3700"	"1450"	"2500"	"1800"
##	[301]	"2000"	"5000"	"2750"	"4000"	"3500"
##	[306]	"2050"	"3000"	"2500"	"3000"	"3450"
##	[311]	"2800"	"2300"	"4000"	"2000"	"2000"
##	[316]	"2920"	"2820"	"3000"	"1300"	"2300"
##	[321]	"2500"	"2000"	"2420"	"2820"	"5000"
##	[326]	"2000"	"2600"	"2100"	"2100"	"3200"
##	[331]	"2200"	"1850"	"3000"	"2000"	"3800"
##	[336]	"1400"	"1450"	"1450"	"1950"	"2200"
##	[341]	"2000"	"2000"	"1800"	"1800"	"2300"
##	[346]	"2000"	"2500"	"2200"	"3000"	"1800"
##	[351]	"1300"	"2000"	"2100"	"2350"	"3000"
##	[356]	"2000"	"4500"	"1800"	"2000"	"2000"
##	[361]	"1800"	"2020"	"2000"	"1600"	"2500"
##	[366]	"2250"	"820"	"820"	"820"	"820"
##	[371]	"2000"	"1500"	"1000"	"2000"	"1600"
##	[376]	"2800"	"2000"	"2000"	"1500"	"1400"
##	[381]	"820"	"620"	"2600"	"2000"	"1800"
##	[386]	"2200"	"1760"	"2800"	"1800"	"1800"
##	[391]	"1100"	"1500"	"1280"	"750"	"1600"
##	[396]	"6000"	"3500"	"3000"	"1300"	"1600"
##	[401]	"1110"	"950"	"820"	"1600"	"1800"
##	[406]	"900"	"2500"	"4250"	"900"	"820"
##	[411]	"820"	"1200"	"800"	"800"	"850"
##	[416]	"1050"	"900"	"750"	"700"	"750"
##	[421]	"750"	"850"	"750"	"560"	"800"
##	[426]	"1450"	"1000"	"1000"	"800"	"800"
##	[431]	"500"	"1200"	"930"	"800"	"800"
##	[436]	"800"	"700"	"750"	"750"	"750"
##	[441]	"850"	"800"	"800"	"800"	"800"
##	[446]	"750"	"750"	"850"	"750"	"750"
##	[451]	"750"	"750"	"800"	"	"650"
##	[456]	"650"	"	"650"	"650"	"500"
##	[461]	"550"	"550"	"600"	"3100"	"3100"
##	[466]	"3080"	"3080"	"3050"	"6020"	"4010"
##	[471]	"4000"	"7000"	"4000"	"2300"	"3000"
##	[476]	"3100"	"2400"	"3150"	"5000"	"3130"
##	[481]	"1800"	"2530"	"2700"	"2000"	"3000"
##	[486]	"1600"	"700"	"3000"	"1700"	"5000"
##	[491]	"2050"	"1950"	"2300"	"1800"	"1950"
##	[496]	"1800"	"2300"	"2200"	"2500"	"2000"
##	[501]	"2000"	"1800"	"4200"	"2400"	"3200"
##	[506]	"2250"	"3000"	"2100"	"1700"	"1700"
##	[511]	"1500"	"1700"	"1500"	"1800"	"1800"
##	[516]	"1800"	"2100"	"2770"	"924034.2"	"1100"
##	[521]	"900"	"1200"	"1000"	"1000"	"1000"
##	[526]	"1250"	"2000"	"1000"	"1000"	"1000"
##	[531]	"650"	"650"	"650"	"650"	"720"

##	[534]	"650"	"650"	"650"	"560"	"750"
##	[536]	"600"	"980"	"600"	"	"600"
##	[541]	"560"	"630"	"650"	"720"	"720"
##	[546]	"900"	"600"	"550"	"600"	"480"
##	[551]	"600"	"620"	"600"	"600"	"680"
##	[556]	"580"	"600"	"900"	"720"	"720"
##	[561]	"600"	"720"	"720"	"720"	"520"
##	[566]	"600"	"600"	"530"	"600"	"4150"
##	[571]	"433"	"21"	"28.5"	"21"	"3000"
##	[576]	"28"	"	"2800"	"3800"	"500019"
##	[581]	"4100"	"3000"	"5680"	"7000"	"4100"
##	[586]	"4000"	"	"6300"	"910"	"910"
##	[591]	"1230"	"1230"	"6300"	"	"1260"
##	[596]	"1140"	"1840"	"1590"	"1100"	"1530"
##	[601]	"1530"	"1530"	"1200"	"1200"	"1200"
##	[606]	"1200"	"1800"	"1800"	"1800"	"1800"
##	[611]	"3000"	"4000"	"3000"	"2500"	"3200"
##	[616]	"2200"	"3000"	"2700"	"2300"	"2800"
##	[621]	"2200"	"2800"	"2840"	"2600"	"2700"
##	[626]	"2840"	"2000"	"2000"	"2000"	"2000"
##	[631]	"2840"	"2840"	"2800"	"2840"	"2600"
##	[636]	"2000"	"2000"	"2000"	"3100"	"5100"
##	[641]	"3340"	"3020"	"6660"	"4360"	"4100"
##	[646]	"3340"	"4500"	"3000"	"2200"	"4100"
##	[651]	"4360"	"3000"	"2100"	"2200"	"3000"
##	[656]	"3400"	"3000"	"4000"	"6660"	"300"
##	[661]	"2200"	"4000"	"3000"	"3000"	"4000"
##	[666]	"3450"	"2700"	"3100"	"2200"	"3000"
##	[671]	"3100"	"4800"	"1730"	"2000"	"2000"
##	[676]	"2550"	"2200"	"2200"	"4360"	"2680"
##	[681]	"2200"	"5000"	"2000"	"1730"	"1950"
##	[686]	"	"1750"	"1350"	"3500"	"3600"
##	[691]	"4100"	"3000"	"2000"	"4800"	"4800"
##	[696]	"4100"	"2000"	"2000"	"2000"	"3000"
##	[701]	"2500"	"4100"	"2000"	"310011.8"	"3000"
##	[706]	"2300"	"2000"	"1730"	"2000"	"1500"
##	[711]	"	"2500"	"2000"	"2300"	"2100"
##	[716]	"6600"	"2000"	"2000"	"4800"	"5000"
##	[721]	"1750"	"4100"	"2000"	"4050"	"1350"
##	[726]	"1350"	"3000"	"2300"	"2400"	"1730"
##	[731]	"1700"	"1050"	"600"	"2150"	"2150"
##	[736]	"2150"	"	"1700"	"4100"	"4100"
##	[741]	"2000"	"1730"	"1650"	"1700"	"2420"
##	[746]	"2150"	"1950"	"1730"	"1500"	"1950"
##	[751]	"4050"	"3000"	"1700"	"1930"	"1400"
##	[756]	"6600"	"2230"	"1400"	"1400"	"2000"
##	[761]	"1400"	"1930"	"1500"	"4100"	"1050"
##	[766]	"12501400"	"1550"	"13501500"	"2600"	"1670"
##	[771]	"1500"	"600"	"	"1000"	"1000"
##	[776]	"1880"	"1000"	"1050"	"1400"	"6600"
##	[781]	"2600"	"1800"	"2600"	"1800"	"1800"
##	[786]	"1900"	"1300"	"800"	"4100"	"4100"
##	[791]	"1000"	"1500"	"1200"	"1200"	"1500"
##	[796]	"900"	"1930"	"1400"	"1400"	"1500"
##	[801]	"1050"	"1000"	"800"	"800"	"1400"
##	[806]	"1200"	"1000"	"1100"	"830"	"3250"
##	[811]	"3250"	"1400"	"1500"	"1200"	"1200"
##	[816]	"1150"	"1000"	"1100"	"	"930"
##	[821]	"2200"	"1050"	"1000"	"1150"	"1150"
##	[826]	"1500"	"1500"	"	"800"	"
##	[831]	"1250"	"1000"	"	"1300"	"
##	[836]	"	"	"	"900"	"900"
##	[841]	"	"	"	"	"
##	[846]	"	"1200"	"1620"	"1530"	"1050"
##	[851]	"1020"	"1000"	"1400"	"1530"	"1400"
##	[856]	"1530"	"1400"	"1660"	"1100"	"1200"
##	[861]	"1100"	"1440"	"1300"	"1190"	"750"
##	[866]	"1200"	"1620"	"1250"	"1050"	"1050"
##	[871]	"1150"	"1200"	"1200"	"1300"	"1050"
##	[876]	"1050"	"1050"	"1200"	"1000"	"
##	[881]	"1500"	"1500"	"1200"	"1000"	"1100"
##	[886]	"1050"	"750"	"700"	"1000"	"1000"
##	[891]	"1100"	"950"	"1050"	"1000"	"1050"

```
## [896] "1050"      "1000"      "830"       "1100"      "1100"
## [901] "1000"      "1000"      "750"       "830"       "1000"
## [906] "1100"      "830"       "850"       "1000"      "750"
## [911] "1000"      "720"       "700"       "720"       "750"
## [916] "750"       "680"       "800"       "2600"      "2000"
## [921] "1600"      "1400"      "2800"      "1000"      "2250"
## [926] "1200"      "1550"      "1200"      "1200"      "2800"
## [931] "2800"      "1550"      "1000"      "6000"      "2800"
## [936] "1000"      "500"       "700"       "2800"      "1600"
## [941] "2800"      "3000"      "800"       "15004"     "2150"
## [946] "1800"      "800"       "1200"      "1200"      "1000"
## [951] "950"       "1000"      "700"       "1200"      "3600"
## [956] "2200"      "700"       "700"       "950"       "1050"
## [961] "850"       "1000"      "800"       "1050"      "1000"
## [966] "1000"      "800"       ""          "1050"      "1050"
## [971] "800"       "800"       "800"       "800"       ""
## [976] "580"       "650"       ""          "830"       ""
## [981] ""          ""          ""          ""          ""
## [986] "650"       "830"       ""          "720"       "680"
## [991] "720"       "720"       "740"       "740"       "740"
## [996] "1300"      "1300"      "1150"      "1150"      "1150"
```

```
# Refinando os resultados ignorando os numeros
mAh <- as.numeric((substring(mAh,1,4)))

mAh[mAh < 100] <- NA
head(mAh,1000)
```

```
## [1] 3400 4080 2000 NA 4020 NA 5000 2000 4420 2870 2000 2000 4000
## [14] 4000 2420 2420 2000 2000 5910 4550 5910 5910 2300 2000 1300 1300
## [27] 2000 2300 2000 2700 2100 3500 2500 1300 4600 NA NA 3700 NA
## [40] NA 1630 2955 2955 4000 2000 3300 1500 2400 7300 4960 4960 2000
## [53] 1300 2000 1760 2640 2710 3420 1300 1500 1500 1300 1460 3260 3260
## [66] 9800 9800 9800 9800 1300 NA 3260 1500 3260 1530 1530 1300 1300
## [79] 1300 1500 1500 1500 1500 1400 1350 1090 1090 970 1500 1350 1350
## [92] 1140 1140 1140 1260 1530 1530 1530 1530 3100 2050 2800 2460 3000
## [105] 2460 5000 2500 5000 3480 4680 2600 4100 3000 7800 341 5900 4130
## [118] 3000 2600 4100 4680 4600 3000 3000 5000 2070 2070 3010 2500 1600
## [131] 2070 400 300 NA 3000 3000 4000 NA NA 2070 5000 3000 3000
## [144] 3000 3000 NA 2400 NA 2500 3030 NA NA 4000 NA NA NA
## [157] 3000 2500 3000 3000 NA 2100 NA 3000 2500 2500 NA 2060 NA
## [170] NA 2110 1750 NA NA NA NA NA NA NA NA NA 2300
## [183] 2300 2400 1820 3230 3300 2110 2110 1200 2060 1170 1500 NA 2400
## [196] 5070 3950 3950 NA NA 3200 NA 6760 NA NA 4270 2400 NA
## [209] 4270 4325 NA 2140 4325 NA NA NA NA NA 4400 NA NA
## [222] 1520 1100 NA 1300 1300 1100 1100 1100 1530 1300 NA 750 NA
## [235] NA 1200 1300 750 1300 720 1300 1300 1000 700 700 920 750
## [248] 720 720 700 5000 3000 2200 2200 2300 3000 3000 4000 2200 4000
## [261] 2500 2500 2500 3000 1800 1700 5000 2800 2500 1400 3000 2800 2000
## [274] 2000 3000 1300 2000 2000 1800 2300 3200 2450 2750 4000 2820 2500
## [287] 4000 2500 2000 2000 2000 3150 3150 2900 2800 2500 3700 1450 2500
## [300] 1800 2000 5000 2750 4000 3500 2050 3000 2500 3000 3450 2800 2300
## [313] 4000 2000 2000 2920 2820 3000 1300 2300 2500 2000 2420 2820 5000
## [326] 2000 2600 2100 2100 3200 2200 1850 3000 2000 3800 1400 1450 1450
## [339] 1950 2200 2000 2000 1800 1800 2300 2000 2500 2200 3000 1800 1300
## [352] 2000 2100 2350 3000 2000 4500 1800 2000 2000 1800 2020 2000 1600
## [365] 2500 2250 820 820 820 820 2000 1500 1000 2000 1600 2800 2000
## [378] 2000 1500 1400 820 620 2600 2000 1800 2200 1760 2800 1800 1800
## [391] 1100 1500 1280 750 1600 6000 3500 3000 1300 1600 1110 950 820
## [404] 1600 1800 900 2500 4250 900 820 820 1200 800 800 850 1050
## [417] 900 750 700 750 750 850 750 560 800 1450 1000 1000 800
## [430] 800 500 1200 930 800 800 800 700 750 750 750 850 800
## [443] 800 800 800 750 750 850 750 750 750 750 800 NA 650
## [456] 650 NA 650 650 500 550 550 600 3100 3100 3080 3080 3050
## [469] 6020 4010 4000 7000 4000 2300 3000 3100 2400 3150 5000 3130 1800
## [482] 2530 2700 2000 3000 1600 700 3000 1700 5000 2050 1950 2300 1800
## [495] 1950 1800 2300 2200 2500 2000 2000 1800 4200 2400 3200 2250 3000
## [508] 2100 1700 1700 1500 1700 1500 1800 1800 1800 2100 2770 9240 1100
## [521] 900 1200 1000 1000 1000 1250 2000 1000 1000 1000 650 650 650
## [534] 560 730 600 980 600 NA 600 560 630 650 720 720 900
## [547] 600 550 600 480 600 620 600 600 680 580 600 900 720
## [560] 720 600 720 720 720 520 600 600 520 600 4150 422 NA
```

```
##      [500]      120      600      120      120      120      320      600      600      330      600      4150      433      NA
##      [573]      NA      NA      3000      NA      NA      2800      3800      5000      4100      3000      5680      7000      4100
##      [586]      4000      NA      6300      910      910      1230      1230      6300      NA      1260      1140      1840      1590
##      [599]      1100      1530      1530      1530      1200      1200      1200      1200      1800      1800      1800      1800      3000
##      [612]      4000      3000      2500      3200      2200      3000      2700      2300      2800      2200      2800      2840      2600
##      [625]      2700      2840      2000      2000      2000      2000      2840      2840      2800      2840      2600      2000      2000
##      [638]      2000      3100      5100      3340      3020      6660      4360      4100      3340      4500      3000      2200      4100
##      [651]      4360      3000      2100      2200      3000      3400      3000      4000      6660      300      2200      4000      3000
##      [664]      3000      4000      3450      2700      3100      2200      3000      3100      4800      1730      2000      2000      2550
##      [677]      2200      2200      4360      2680      2200      5000      2000      1730      1950      NA      1750      1350      3500
##      [690]      3600      4100      3000      2000      4800      4800      4100      2000      2000      2000      3000      2500      4100
##      [703]      2000      3100      3000      2300      2000      1730      2000      1500      NA      2500      2000      2300      2100
##      [716]      6600      2000      2000      4800      5000      1750      4100      2000      4050      1350      1350      3000      2300
##      [729]      2400      1730      1700      1050      600      2150      2150      2150      NA      1700      4100      4100      2000
##      [742]      1730      1650      1700      2420      2150      1950      1730      1500      1950      4050      3000      1700      1930
##      [755]      1400      6600      2230      1400      1400      2000      1400      1930      1500      4100      1050      1250      1550
##      [768]      1350      2600      1670      1500      600      NA      1000      1000      1880      1000      1050      1400      6600
##      [781]      2600      1800      2600      1800      1800      1900      1300      800      4100      4100      1000      1500      1200
##      [794]      1200      1500      900      1930      1400      1400      1500      1050      1000      800      800      1400      1200
##      [807]      1000      1100      830      3250      3250      1400      1500      1200      1200      1150      1000      1100      NA
##      [820]      930      2200      1050      1000      1150      1150      1500      1500      NA      800      NA      1250      1000
##      [833]      NA      1300      NA      NA      NA      NA      900      900      NA      NA      NA      NA      NA
##      [846]      NA      1200      1620      1530      1050      1020      1000      1400      1530      1400      1530      1400      1660
##      [859]      1100      1200      1100      1440      1300      1190      750      1200      1620      1250      1050      1050      1150
##      [872]      1200      1200      1300      1050      1050      1050      1200      1000      NA      1500      1500      1200      1000
##      [885]      1100      1050      750      700      1000      1000      1100      950      1050      1000      1050      1050      1000
##      [898]      830      1100      1100      1000      1000      750      830      1000      1100      830      850      1000      750
##      [911]      1000      720      700      720      750      750      680      800      2600      2000      1600      1400      2800
##      [924]      1000      2250      1200      1550      1200      1200      2800      2800      1550      1000      6000      2800      1000
##      [937]      500      700      2800      1600      2800      3000      800      1500      2150      1800      800      1200      1200
##      [950]      1000      950      1000      700      1200      3600      2200      700      700      950      1050      850      1000
##      [963]      800      1050      1000      1000      800      NA      1050      1050      800      800      800      800      NA
##      [976]      580      650      NA      830      NA      NA      NA      NA      NA      NA      650      830      NA
##      [989]      720      680      720      720      740      740      740      1300      1300      1150      1150      1150
```

```
summary(mAh)
```

```
##      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.      NA's
##      300      950      1600      1959      2500      9800      266
```

```
#install.packages("anytime")
library(anytime)
```

```
## Warning: package 'anytime' was built under R version 3.5.2
```

```
rdates <- anydate(phones$announced)
head(rdates,1000)
```

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## [946] "2012-10-01" "2012-10-01" "2012-10-01" "2012-10-01" "2012-08-01"
## [951] "2012-08-01" "2012-05-01" "2012-05-01" "2012-05-01" "2012-04-01"
## [956] "2012-01-01" "2012-03-01" "2012-01-01" "2012-01-01" "2011-12-01"
## [961] "2011-10-01" "2011-10-01" "2011-10-01" "2011-09-01" "2011-08-01"
## [966] "2011-05-01" "2011-08-01" "2011-06-01" NA "2011-06-01"
## [971] "2011-06-01" NA "2011-05-01" "2011-05-01" "2011-04-01"
## [976] NA NA "2005-07-01" "2005-06-01" "2004-04-01"
## [981] NA "2004-01-01" "2005-02-01" "2004-01-01" "2004-01-01"
## [986] "2004-01-01" "2004-02-01" "2004-01-01" "2004-01-01" "2004-01-01"
## [991] "2004-01-01" "2004-01-01" "2003-04-01" "2003-04-01" "2003-04-01"
## [996] "2011-02-01" "2011-02-01" NA NA NA
```

```
summary(rdates)
```

```
##      Min.      1st Qu.      Median      Mean      3rd Qu.
## "1996-01-01" "2011-01-01" "2013-09-01" "2012-02-05" "2015-07-01"
##      Max.      NA's
## "2017-06-01"      "551"
```

```
modeldb <- data.frame(rdates, mAh)
summary(modeldb)
```

```
##      rdates      mAh
## Min. :1996-01-01 Min. : 300
## 1st Qu.:2011-01-01 1st Qu.: 950
## Median :2013-09-01 Median :1600
## Mean :2012-02-05 Mean :1959
## 3rd Qu.:2015-07-01 3rd Qu.:2500
## Max. :2017-06-01 Max. :9800
## NA's :551 NA's :266
```



```
# Limpando observacoes que tem algum NA, informacao faltando, em uma variavel e nas duas.
#modeldb_clean <- na.omit(modeldb)
#summary(modeldb_clean$rdates)

#mod1 <- lm(log(modeldb_clean$mAh)~modeldb_clean$rdates)
#summary(mod1)

# b2 <- coef(mod1)[[2]]
# g <- b2*100
# g

# Crescimento de 2,67% por dia/mês???

# Indexando para ano
library(lubridate)
```

```
##
## Attaching package: 'lubridate'
```

```
## The following object is masked from 'package:base':
##
##      date
```

```
years <- year(rdates)
head(years,1000)
```

```
##      [1] 2016 2016 2016 2016 2016 2015 2016 2016 2016 2015 2015 2015 2015 2015
##      [14] 2015 2015 2015 2015 2015 2015 2015 2015 2014 2014 2015 2015 2015 2015
##      [27] 2015 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014  NA
##      [40] 2014 2014 2014 2014 2014 2014 2014 2013 2013 2013 2013  NA 2013 2013
##      [53] 2013 2013 2013 2013 2013 2012 2012 2012 2012 2012 2012 2012  NA 2012
##      [66] 2012 2012 2012 2012 2011 2011  NA 2011  NA  NA 2011 2011 2011
##      [79]  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA
##      [92]  NA  NA  NA  NA  NA  NA  NA  NA  NA 2017 2017 2017 2017 2017
##     [105] 2016 2016 2016 2015 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016
##     [118] 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2015
##     [131] 2016 2016 2015 2015 2014 2015 2015 2015 2016 2016 2015 2015 2015 2015
##     [144] 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015
##     [157] 2015 2015 2015 2015 2015 2015 2015 2015 2015 2014 2014 2014 2014 2014
##     [170] 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014
##     [183] 2014 2014 2014 2014 2014 2015 2014 2014 2014 2014 2014 2013 2013 2013
##     [196] 2013 2013 2013 2013  NA 2013 2013 2013 2013 2013 2013 2013 2013 2013
##     [209] 2013 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2011
##     [222] 2012  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA 2007
##     [235] 2007  NA 2007 2007 2007 2006 2006 2006 2006 2006 2006 2006 2006 2006
##     [248] 2006 2006 2005 2017  NA 2016 2016 2016 2016 2016 2016 2016 2016 2016
##     [261] 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016
##     [274] 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016
##     [287] 2016 2016 2016 2016 2016 2016 2016 2016 2015 2015 2015 2015 2015 2015
##     [300] 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015
##     [313] 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015
##     [326] 2015 2015 2015 2015 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014
##     [339] 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014
##     [352] 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2013 2013 2013 2013
##     [365] 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013  NA 2013 2013
##     [378] 2013 2013 2013 2013 2013 2013  NA  NA  NA  NA  NA  NA  NA  NA
##     [391] 2012  NA  NA  NA 2012  NA 2012 2012 2012  NA  NA  NA 2011 2012
##     [404]  NA 2012 2012 2011 2011 2011 2011 2011 2011 2011 2011 2011 2011 2011
##     [417] 2011 2011 2011 2011 2011 2011 2011 2011 2011 2011  NA  NA 2011 2011
##     [430]  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA
##     [443]  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA 1999 1999
##     [456] 1998 1999 1996 1996 1996 1999 1997 1997 2017 2017 2016 2016 2016
##     [469] 2016 2017 2017 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016
##     [482] 2016 2016 2015 2015 2014 2014 2015 2015 2014 2014 2015 2014 2014
##     [495] 2014  NA 2014 2013 2013 2013 2013 2013 2014 2014 2014 2013 2013
##     [508] 2013 2013 2013 2013 2013 2013 2013 2013 2014 2013 2013 2016 2015  NA
##     [521]  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA
##     [534] 2006 2006 2006 2006 2005 2005 2005 2005 2006 2006 2006 2006 2006  NA
##     [547]  NA 2005 2005 2005 2004 2004 2004 2004 2004 2004 2004 2004 2004 2004
```

```
##      [547]      NA 2003 2003 2003 2004 2004 2004 2004 2004 2004 2004 2004 2004
## [560] 2004 2004 2004 2004 2004 2003 2004 2004 2004 2004 2004 2016 2014 2015
## [573] 2015 2015 2014 2014 2014 2014 2014 2014 2014 2014 2014 2013 2013 2013
## [586] 2013 2013 2011 2011 2011 2011 2011      NA      NA      NA      NA      NA 2007
## [599] 2007 2006 2006 2006 2006 2006 2005 2005 2004 2004 2004 2004 2004 2017
## [612] 2017 2017 2017 2017 2015 2016 2016 2016 2016 2016 2016 2016 2016 2015
## [625] 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2014
## [638] 2015 2015 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016
## [651] 2016 2016 2016 2016 2016 2016 2016 2016 2016 2016 2015 2015 2015 2015
## [664] 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015
## [677] 2015 2015 2015 2015 2015 2015 2015 2015 2015 2015      NA 2014 2014 2014
## [690] 2014 2014 2014 2014 2015 2014 2015 2014 2014 2014 2014 2014 2014 2014
## [703] 2014 2014 2014 2014      NA      NA 2014 2014 2014 2014 2014 2014 2014
## [716] 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2013 2013 2013 2013
## [729] 2013 2013 2013      NA      NA 2013 2013 2013 2013 2013 2013 2013 2013
## [742] 2013 2013 2013 2013 2013 2013 2013 2013      NA 2013 2013 2013 2013 2012
## [755] 2012 2013 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012      NA
## [768] 2012 2012 2012 2012      NA 2012      NA      NA 2012 2011 2012 2012 2012
## [781] 2012 2012 2012 2012 2012 2011 2011 2011      NA      NA 2011 2011 2011
## [794] 2011 2011 2011 2011 2011 2011      NA      NA 2011      NA 2011 2011 2011
## [807]      NA 2010      NA 2011      NA 2010 2010      NA      NA      NA      NA 2010      NA
## [820]      NA      NA      NA      NA      NA      NA      NA      NA      NA      NA      NA      NA      NA
## [833]      NA      NA      NA      NA      NA      NA 2008      NA 2008 2008 2008      NA      NA
## [846]      NA      NA      NA      NA      NA 2007 2007 2007 2007 2007      NA 2007 2007
## [859] 2006 2006 2006 2006 2006 2006 2006 2006 2005 2005 2005 2005 2005
## [872] 2005 2004 2004 2004 2004 2004 2004 2004 2004 2004      NA      NA      NA      NA
## [885]      NA      NA      NA      NA      NA      NA      NA      NA 2009      NA      NA      NA      NA
## [898]      NA      NA      NA      NA      NA      NA      NA      NA 2007      NA      NA      NA      NA
## [911]      NA      NA      NA      NA      NA      NA      NA 2016 2015 2015 2015 2015 2014
## [924] 2014      NA 2014 2014 2014 2014 2014 2014 2014 2014 2014 2014 2013 2013
## [937] 2013 2013 2013 2013 2013 2013 2011 2012 2012 2012 2012 2012 2012 2012
## [950] 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2011 2011 2011
## [963] 2011 2011 2011 2011 2011 2011      NA 2011 2011      NA 2011 2011 2011
## [976]      NA      NA 2005 2005 2004      NA 2004 2005 2004 2004 2004 2004 2004
## [989] 2004 2004 2004 2004 2003 2003 2003 2011 2011      NA      NA      NA
```

```
summary(years)
```

```
##      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.      NA's
##      1996     2011     2013     2012     2015     2017       551
```

```
mod_db2 <- data.frame(years, mAh)
mod_db2c <- na.omit(mod_db2)
head(mod_db2c)
```

```
##      years  mAh
## 1  2016 3400
## 2  2016 4080
## 3  2016 2000
## 5  2015 4020
## 7  2016 5000
## 8  2016 2000
```

```
mod2 <- lm(log(mAh)~years, data = mod_db2c)
summary(mod2)
```

```
##
## Call:
## lm(formula = log(mAh) ~ years, data = mod_db2c)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.06333 -0.22846 -0.01786  0.21523  2.31899
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -192.84357     4.72782  -40.79  <2e-16 ***
## years         0.09956     0.00235   42.37  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4439 on 2013 degrees of freedom
## Multiple R-squared:  0.4714, Adjusted R-squared:  0.4712
## F-statistic: 1795 on 1 and 2013 DF,  p-value: < 2.2e-16
```

```
b1_mod2 <- coef(mod2)[[1]]
b2_mod2 <- coef(mod2)[[2]]
g2 <- b2_mod2*100
g2
```

```
## [1] 9.955865
```

```
# Taxa de crescimento de 9,96% ao ano.

#g2/g
# 373.. devia estar em dias
sig2 <- sqrt(deviance(mod2)/df.residual(mod2))
df <- df.residual(mod2)
# nao funcionou rse <- sum(resid(mod2)^2)/df

##### PREVISOES #####
yhat18 <- exp(b1_mod2 + b2_mod2 * 2018 + (sig2/2))
yhat18
```

```
## [1] 3974.87
```

```
yhat19 <- exp(b1_mod2 + b2_mod2 * 2019 + (sig2/2))
yhat19
```

```
## [1] 4390.973
```

```
# Previsao 2020
yhat20 <- exp(b1_mod2 + b2_mod2 * 2020 + (sig2/2))
yhat20
```

```
## [1] 4850.634
```

```
# Media prevista para 2020 de 4850 mAh

# Previsao 2021
yhat21 <- exp(b1_mod2 + b2_mod2 * 2021 + (sig2/2))
yhat21
```

```
## [1] 5358.414
```

```
# Media prevista para 2021 de 5358 mAh
```

```
# Previsao 2022
```

```
yhat22 <- exp(b1_mod2 + b2_mod2 * 2022 + (sig2/2))  
yhat22
```

```
## [1] 5919.35
```

```
# Media prevista para 2022 de 5919 mAh
```

```
# Previsao 2023
```

```
yhat23 <- exp(b1_mod2 + b2_mod2 * 2023 + (sig2/2))  
yhat23
```

```
## [1] 6539.007
```

```
# Media prevista para 2023 de 6539 mAh
```

```
# Previsao 2024
```

```
yhat24 <- exp(b1_mod2 + b2_mod2 * 2024 + (sig2/2))  
yhat24
```

```
## [1] 7223.532
```

```
# Media prevista para 2024 de 7223 mAh
```

```
# Previsao 2025
```

```
yhat25 <- exp(b1_mod2 + b2_mod2 * 2025 + (sig2/2))  
yhat25
```

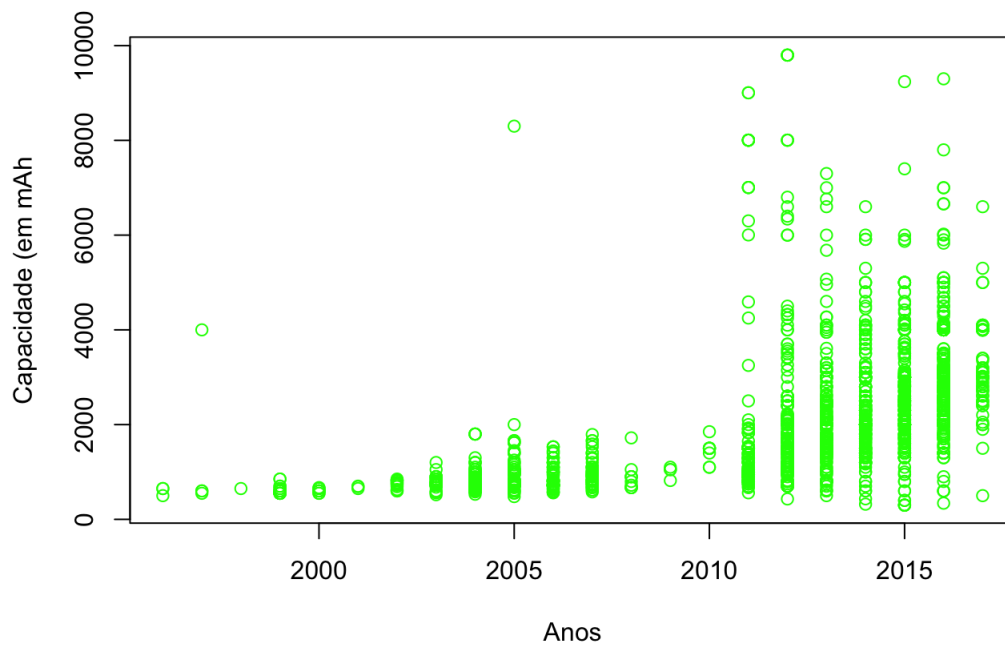
```
## [1] 7979.715
```

```
# Media prevista para 2025 de 7979 mAh
```

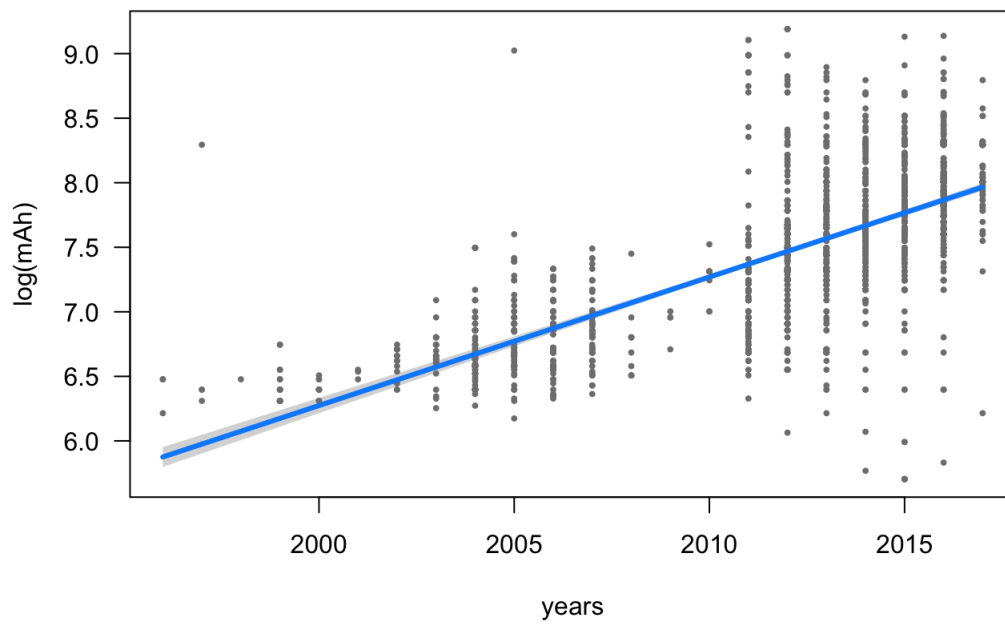
```
##### GRAFICOS E TESTE BP #####
```

```
plot(mod_db2c$years, mod_db2c$mAh, col="green",  
      xlab = "Anos",  
      ylab = "Capacidade (em mAh)")
```

```
library(visreg)
```



```
visreg(mod2, "years")
```



```
library(lmtest)
```

```
## Warning: package 'lmtest' was built under R version 3.5.2
```

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

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

```
## The following objects are masked from 'package:base':
##
##   as.Date, as.Date.numeric
```

```
bptest(mod2)
```

```
##
## studentized Breusch-Pagan test
##
## data: mod2
## BP = 2.3604, df = 1, p-value = 0.1245
```

```
#### PLOTAR PREVISÕES
```

```
hats <- c(3224.68, yhat18, yhat19, yhat20, yhat21, yhat22, yhat23, yhat24, yhat25)
hats
```

```
## [1] 3224.680 3974.870 4390.973 4850.634 5358.414 5919.350 6539.007 7223.532
## [9] 7979.715
```

```
# install.packages("tidyverse")
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 3.5.2
```

```
## — Attaching packages —————
## tidyverse 1.3.0 —
```

```
## ✓ ggplot2 3.3.0      ✓ purrr 0.3.4
## ✓ tibble 3.0.1       ✓ dplyr 0.8.5
## ✓ tidyr 1.0.3        ✓ stringr 1.4.0
## ✓ readr 1.3.1        ✓ forcats 0.4.0
```

```
## Warning: package 'ggplot2' was built under R version 3.5.2
```

```
## Warning: package 'dplyr' was built under R version 3.5.2
```

```
## Warning: package 'stringr' was built under R version 3.5.2
```

```
## Warning: package 'forcats' was built under R version 3.5.2
```

```
## — Conflicts ————— tidyverse_conflicts() —
## * lubridate::as.difftime() masks base::as.difftime()
## * lubridate::date()        masks base::date()
## * dplyr::filter()          masks stats::filter()
## * lubridate::intersect()   masks base::intersect()
## * dplyr::lag()              masks stats::lag()
## * lubridate::setdiff()     masks base::setdiff()
## * lubridate::union()       masks base::union()
```

```

years_avg <- mod_db2c %>%
  group_by(years) %>%
  summarise(year_avg = mean(mAh))
hatsyears <- c(2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025)
hatsdframe <- data.frame(hatsyears, hats)

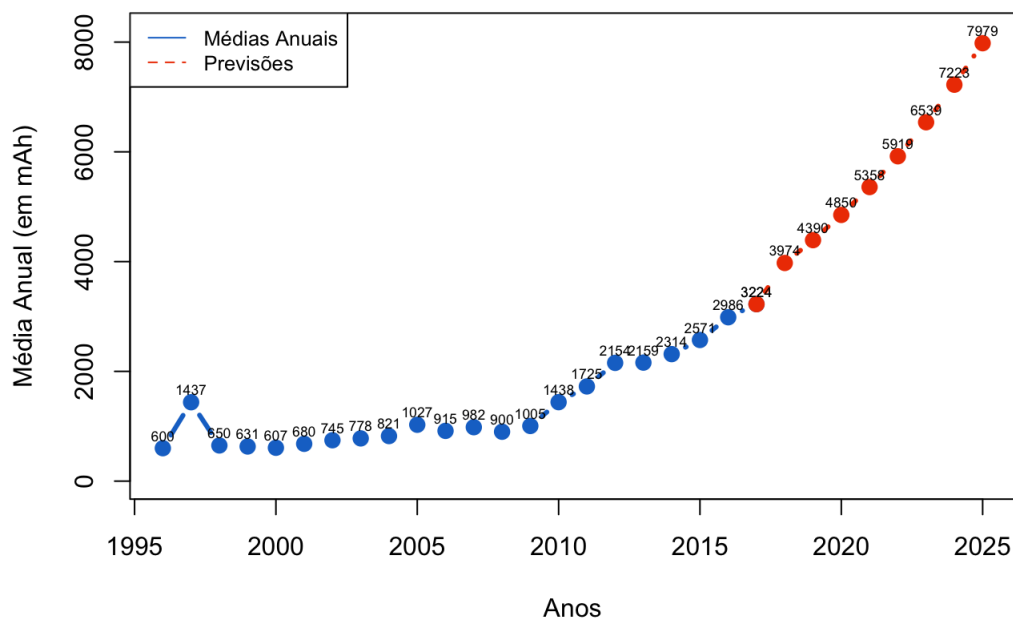
mainplot_y <- as.numeric(substring(years_avg$year_avg,1,4))
plot(years_avg$years, years_avg$year_avg,
  type = "b", lty = 1, lwd = 3,
  xlab = "Anos",
  ylab = "Média Anual (em mAh)", col = "dodgerblue3",
  main = "Evolução da Capacidade de Baterias de Celulares",
  xlim = range(c(1996:2025)), ylim = range(c(0:8200)), pch=19)
text(years_avg$years, mainplot_y+230, labels=as.character(mainplot_y), cex = 0.55)

lines(hatsyears, hats, type = "b", lty = 3, lwd = 3, pch=19, col = "orangered2")
text(hatsyears, hats+230, label=as.character(substring(hats, 1, 4)), cex = 0.55)

legend("topleft", legend=c("Médias Anuais", "Previsões"),
  col=c("dodgerblue3", "orangered2"), lty = 1:2, cex=0.8)

```

Evolução da Capacidade de Baterias de Celulares

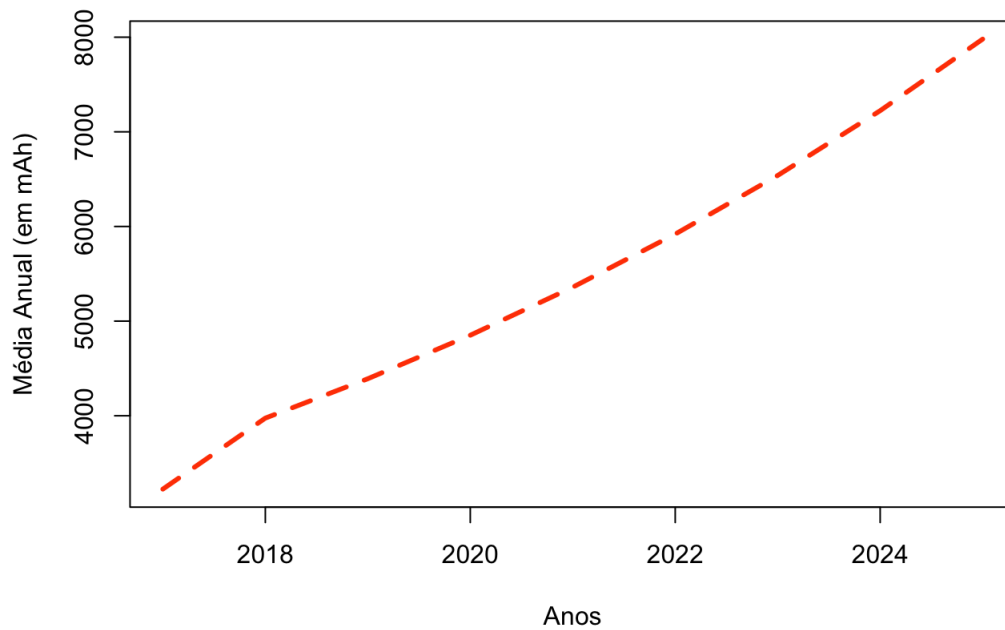


```

plot(hatsyears, hats,
  type = "l", lty = 2, lwd = 3,
  xlab = "Anos",
  ylab = "Média Anual (em mAh)", col = "orangered",
  main = "Evolução da Capacidade de Baterias de Celulares",
  xlim = range(hatsyears), ylim = range(hats), pch=19)

```

Evolução da Capacidade de Baterias de Celulares



```
# plot(x, f_x, xlim=range(x), ylim=range(f_x), xlab="x", ylab="y",  
# main = "noise-less data", pch=16)  
# lines(x[order(x)], f_x[order(x)], xlim=range(x), ylim=range(f_x), pch=16)
```

```
library(lmtest)  
bptest(mod2)
```

```
##  
## studentized Breusch-Pagan test  
##  
## data: mod2  
## BP = 2.3604, df = 1, p-value = 0.1245
```

```
# Nao podemos rejeitar a homocedasticidade do modelo, pois nao há evidencias estatisticas para tal com um p-  
valor=0.1245
```

```
library(faraway)  
vif(mod2)
```

```
## years  
## 1
```

```
# Nao há multicolinearidade
```

```
freqyear <- table(mod_db2c$years)  
freqyear
```

```
##  
## 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010  
## 3 4 1 16 9 3 14 31 85 83 80 60 10 4 9  
## 2011 2012 2013 2014 2015 2016 2017  
## 168 202 231 257 350 331 64
```

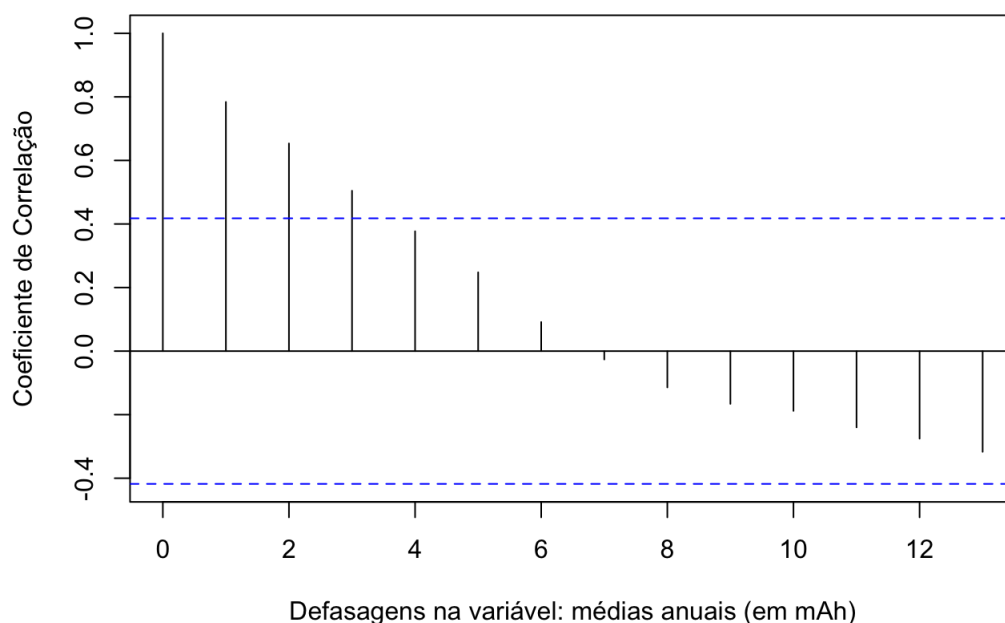
```
##### AR  
library(tidyverse)  
years_avg <- mod_db2c %>%  
  group_by(years) %>%  
  summarise(year_avg = mean(mAh))  
years_avg
```



```
## # A tibble: 22 x 2
##   years year_avg
##   <dbl>   <dbl>
## 1 1996     600
## 2 1997   1438.
## 3 1998     650
## 4 1999     631.
## 5 2000     608.
## 6 2001     680
## 7 2002     745
## 8 2003     779.
## 9 2004     821.
## 10 2005   1027.
## # ... with 12 more rows
```

```
view(years_avg)
```

```
yavg.ts <- ts(years_avg$year_avg, start = c(1996, 1), end = c(2017,1), frequency = 1)
acf(yavg.ts, main="", xlab="Defasagens na variável: médias anuais (em mAh)", ylab="Coeficiente de Correlação")
```



```
yavg.ts
```

```
## Time Series:
## Start = 1996
## End = 2017
## Frequency = 1
## [1] 600.0000 1437.5000 650.0000 631.2500 607.7778 680.0000 745.0000
## [8] 778.7097 821.1765 1027.2289 915.7500 982.8333 900.0000 1005.0000
## [15] 1438.8889 1725.4464 2154.5693 2159.5238 2314.2529 2571.7429 2986.0453
## [22] 3224.6875
```

```
library(dynlm)
```

```
## Warning: package 'dynlm' was built under R version 3.5.2
```

```
ar2 <- dynlm(yavg.ts ~ yavg.ts + L(yavg.ts, 1) + L(yavg.ts, 2), data = yavg.ts)
```

```
## Warning in model.matrix.default(mt, mf, contrasts): the response appeared
## on the right-hand side and was dropped
```

```
## Warning in model.matrix.default(mt, mf, contrasts): problem with term 1 in
## model.matrix: no columns are assigned
```

```
summary(ar2)
```

```
##
## Time series regression with "ts" data:
## Start = 1998, End = 2017
##
## Call:
## dynlm(formula = yavg.ts ~ yavg.ts + L(yavg.ts, 1) + L(yavg.ts,
##      2), data = yavg.ts)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -602.39 -109.76   4.39   95.60  399.65
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -113.1813   117.8215  -0.961 0.350210
## L(yavg.ts, 1)    0.7782    0.1777   4.379 0.000409 ***
## L(yavg.ts, 2)    0.4114    0.2044   2.013 0.060283 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 240.4 on 17 degrees of freedom
## Multiple R-squared:  0.9283, Adjusted R-squared:  0.9199
## F-statistic: 110.1 on 2 and 17 DF,  p-value: 1.866e-10
```

```
# testes
library(lmtest)
bptest(ar2)
```

```
## Warning in model.matrix.default(terms(formula), model.frame(formula)): the
## response appeared on the right-hand side and was dropped
```

```
## Warning in model.matrix.default(terms(formula), model.frame(formula)):
## problem with term 1 in model.matrix: no columns are assigned
```

```
##
## studentized Breusch-Pagan test
##
## data: ar2
## BP = 3.867, df = 2, p-value = 0.1446
```

```
# Nao ha evidencias estatisticas para rejeitarmos a hipotese H0 da homocedasticidade.
# Portanto nao podemos afirmar que o modelo é heterocedastico.
```

```
armod <- ar(yavg.ts, aic=TRUE, method="ols", order.max = 2)
armod
```

```
##
## Call:
## ar(x = yavg.ts, aic = TRUE, order.max = 2, method = "ols")
##
## Coefficients:
##      1      2
## 0.7782 0.4114
##
## Intercept: 148.5 (55.46)
##
## Order selected 2  sigma^2 estimated as  49120
```

```
library(forecast)
```

```
## Warning: package 'forecast' was built under R version 3.5.2
```

```
fc10 <- data.frame(forecast(armod, 10))
```

```
## Warning in object$var.pred * vars: Recycling array of length 1 in array-vector arithmetic is deprecated.
## Use c() or as.vector() instead.
```

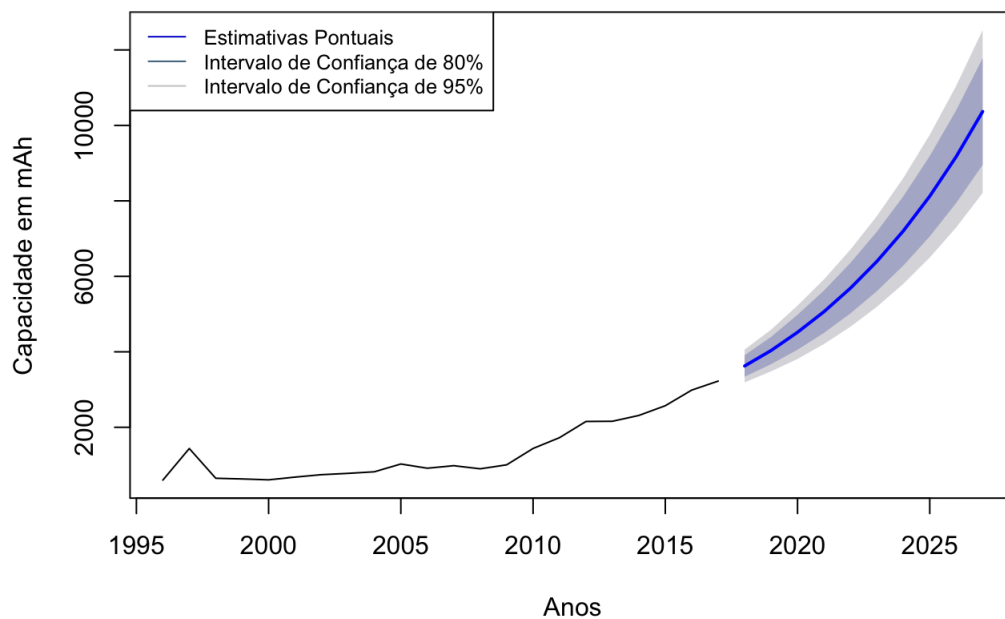
```
fc10
```

```
##      Point.Forecast  Lo.80  Hi.80  Lo.95  Hi.95
## 2018      3624.955 3340.925 3908.985 3190.568 4059.342
## 2019      4034.642 3674.737 4394.547 3484.215 4585.069
## 2020      4518.160 4056.657 4979.663 3812.353 5223.968
## 2021      5063.011 4503.824 5622.198 4207.808 5918.214
## 2022      5685.971 5018.424 6353.518 4665.046 6706.896
## 2023      6394.951 5609.630 7180.273 5193.906 7595.997
## 2024      7203.014 6286.800 8119.227 5801.786 8604.241
## 2025      8123.577 7061.355 9185.799 6499.049 9748.106
## 2026      9172.459 7946.325 10398.592 7297.250 11047.667
## 2027     10367.489 8956.720 11778.257 8209.904 12525.073
```

```
plot(forecast(armod, 10), main = "", xlab = "Anos", ylab = "Capacidade em mAh")
```

```
## Warning in object$var.pred * vars: Recycling array of length 1 in array-vector arithmetic is deprecated.
## Use c() or as.vector() instead.
```

```
legend("topleft", legend=c("Estimativas Pontuais", "Intervalo de Confiança de 80%", "Intervalo de Confiança de 95%"),
      col=c("blue3", "skyblue4", "gray80"), lty = 1, cex=0.8)
```



```
####

plotForecastErrors <- function(forecasterrors)
{
  # make a histogram of the forecast errors:
  mybinsize <- IQR(forecasterrors)/4
  mysd <- sd(forecasterrors)
  mymin <- min(forecasterrors) - mysd*5
  mymax <- max(forecasterrors) + mysd*3
  # generate normally distributed data with mean 0 and standard deviation mysd
  mynorm <- rnorm(10000, mean=0, sd=mysd)
  mymin2 <- min(mynorm)
  mymax2 <- max(mynorm)
  if (mymin2 < mymin) { mymin <- mymin2 }
  if (mymax2 > mymax) { mymax <- mymax2 }
  # make a red histogram of the forecast errors, with the normally distributed data overlaid:
  mybins <- seq(mymin, mymax, mybinsize)
  hist(forecasterrors, col="red", freq=FALSE, breaks=mybins)
  # freq=FALSE ensures the area under the histogram = 1
  # generate normally distributed data with mean 0 and standard deviation mysd
  myhist <- hist(mynorm, plot=FALSE, breaks=mybins)
  # plot the normal curve as a blue line on top of the histogram of forecast errors:
  points(myhist$mids, myhist$density, type="l", col="blue", lwd=2)
}

plotForecastErrors(ar2$residuals)
```

Histogram of forecasterrors

