MACHINE LEARNING ALGORITHMS: REVIEW 1

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```r
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#MARKET BASKET ANALYSIS


library(ElemStatLearn)
```

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

```r
library(MASS)
fix(ElemStatLearn)
names(marketing)
```

```
##  [1] "Income"       "Sex"          "Marital"      "Age"          "Edu"
##  [6] "Occupation"   "Lived"        "Dual_Income"  "Household"    "Householdu18"
## [11] "Status"       "Home_Type"    "Ethnic"       "Language"
```

```r
market=marketing[ ! marketing$Marital %in% c(NA), ]
market=market[ ! market$Edu %in% c(NA), ]
market=market[ ! market$Occupation %in% c(NA), ]
market=market[ ! market$Lived %in% c(NA), ]
market=market[ ! market$Household %in% c(NA), ]
market=market[ ! market$Status %in% c(NA), ]
market=market[ ! market$Home_Type %in% c(NA), ]
market=market[ ! market$Ethnic %in% c(NA), ]
market=market[ ! market$Language %in% c(NA), ]
dim(market)
```

```
## [1] 6876   14
```

```r
attach(market)

#Linear Discriminant Analysis (LDA) fit
train=(Age<7)
market.7=market[!train,]
dim(market.7)
```

```
## [1] 393  14
```

```r
Income.7=Income[!train]
lda.fit=lda(Income~Household+Edu+Lived+Occupation+Dual_Income+Language,data=market,subset=train)
lda.fit
```

```
## Call:
## lda(Income ~ Household + Edu + Lived + Occupation + Dual_Income +
##     Language, data = market, subset = train)
##
## Prior probabilities of groups:
##          1          2          3          4          5          6          7
## 0.18849298 0.07542804 0.07141755 0.08730526 0.07465679 0.12093167 0.11491593
##          8          9
## 0.15687182 0.10997995
##
## Group means:
##    Household      Edu    Lived Occupation Dual_Income Language
## 1   3.599018 2.770049 4.134206   5.416530    1.093290 1.201309
## 2   2.809816 3.578732 3.858896   4.120654    1.306748 1.139059
## 3   2.673866 3.805616 4.045356   3.481641    1.276458 1.144708
## 4   2.408127 3.848057 4.070671   3.160777    1.365724 1.109541
## 5   2.520661 3.997934 4.055785   2.981405    1.450413 1.119835
## 6   2.677296 4.077806 4.179847   2.911990    1.633929 1.080357
## 7   2.797315 4.268456 4.361074   2.900671    1.711409 1.116779
## 8   2.931170 4.371681 4.371681   2.637168    1.839725 1.071780
## 9   3.086957 4.730715 4.295933   2.417952    1.886396 1.077139
##
## Coefficients of linear discriminants:
##                     LD1         LD2        LD3         LD4         LD5
## Household   -0.02897832  0.5574908 -0.2577280  0.02604659  0.3521162
## Edu          0.51876742  0.2318416 -0.6855858  0.21082247 -0.2679512
## Lived        0.13450287  0.2067115  0.3929392  0.61683334 -0.1048490
## Occupation  -0.23229126  0.1479889 -0.1040201 -0.07598921 -0.3246440
## Dual_Income  0.91605810  0.3658391  0.7752017 -0.75098157 -0.4867861
## Language    -0.14208940 -0.1179249 -0.2578604  1.16023813 -1.1956801
##                     LD6
## Household    0.08330768
## Edu         -0.28568027
## Lived       -0.28143579
## Occupation  -0.19342157
## Dual_Income  0.37051520
## Language     1.83999121
##
## Proportion of trace:
##    LD1    LD2    LD3    LD4    LD5    LD6
## 0.9079 0.0747 0.0108 0.0046 0.0018 0.0002
```

```
plot(lda.fit)
```
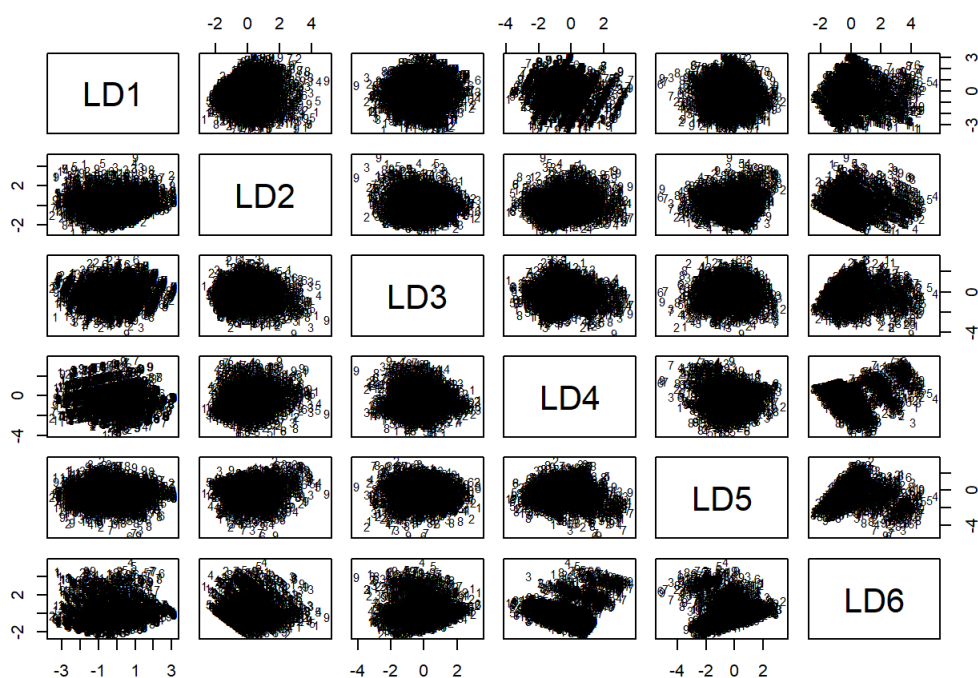
```
lda.pred=predict(lda.fit, market.7)
names(lda.pred)
```

```
## [1] "class"     "posterior" "x"
```

```
lda.class=lda.pred$class
table(lda.class,Income.7)
```

```
##          Income.7
## lda.class  1  2  3  4  5  6  7  8  9
##        1 26 28 18 25 11 12 11 12  5
##        2  0  1  1  0  0  1  0  1  0
##        3  0  0  0  0  0  0  0  0  0
##        4  2  0  1  1  1  0  1  0  0
##        5  0  0  0  0  0  0  0  0  0
##        6  1  0  1  1  1  1  3  3  0
##        7  1  2  0  2  0  1  1  1  3
##        8  3  9 20 22 29 44 21 33 19
##        9  0  0  1  1  1  3  2  2  3
```

```
mean(lda.class==Income.7)
```

```
## [1] 0.1679389
```

```
sum(lda.pred$posterior[,1]>=.5)
```

```
## [1] 46
```

```
sum(lda.pred$posterior[,1]<.5)
```

```
## [1] 347
```

```
lda.pred$posterior[1:20,1]
```

```
##          10           30           37           64           96           99
## 0.0523680793 0.5438202263 0.0271799954 0.2543632088 0.1019153553 0.6120886951
##         116          142          143          147          149          161
## 0.0434754442 0.0039844445 0.0001741028 0.1228781120 0.1019153553 0.0001741028
##         166          175          178          181          185          213
## 0.1094117554 0.0434754442 0.2324361488 0.0166403333 0.0056867130 0.0166403333
##         230          237
## 0.1799972885 0.0517744079
```

```
lda.class[1:20]
```

```
##  [1] 8 1 8 1 8 1 8 8 9 8 8 9 4 8 1 8 8 8 1 8
## Levels: 1 2 3 4 5 6 7 8 9
```

```
sum(lda.pred$posterior[,1]>.9)
```

```
## [1] 0
```

```
#K Nearest Neighbour
library(ElemStatLearn)
library(MASS)
fix(ElemStatLearn)
names(marketing)
```

```
##  [1] "Income"      "Sex"         "Marital"      "Age"         "Edu"
##  [6] "Occupation"  "Lived"       "Dual_Income"  "Household"   "Householdu18"
## [11] "Status"      "Home_Type"   "Ethnic"       "Language"
```

```
market=marketing[ ! marketing$Marital %in% c(NA), ]
market=market[ ! market$Edu %in% c(NA), ]
market=market[ ! market$Occupation %in% c(NA), ]
market=market[ ! market$Lived %in% c(NA), ]
market=market[ ! market$Household %in% c(NA), ]
market=market[ ! market$Status %in% c(NA), ]
market=market[ ! market$Home_Type %in% c(NA), ]
market=market[ ! market$Ethnic %in% c(NA), ]
market=market[ ! market$Language %in% c(NA), ]
dim(market)
```

```
## [1] 6876    14
```

```
data(market)
```

```
## Warning in data(market): data set 'market' not found
```

```
str(market)
```

```
## 'data.frame':    6876 obs. of  14 variables:
##  $ Income      : int  9 9 1 1 8 1 6 2 4 1 ...
##  $ Sex         : int  1 2 2 2 1 1 1 1 1 1 ...
##  $ Marital     : int  1 1 5 5 1 5 3 1 1 5 ...
##  $ Age         : int  5 3 1 1 6 2 3 6 7 2 ...
##  $ Edu         : int  5 5 2 2 4 3 4 3 4 4 ...
##  $ Occupation  : int  5 1 6 6 8 9 3 8 8 9 ...
##  $ Lived       : int  5 5 5 3 5 4 5 5 4 5 ...
##  $ Dual_Income : int  3 2 1 1 3 1 1 3 3 1 ...
##  $ Household   : int  5 3 4 4 2 3 1 3 2 1 ...
##  $ Householdu18: int  2 1 2 2 0 1 0 0 0 0 ...
##  $ Status      : int  1 2 3 3 1 2 2 2 2 2 ...
##  $ Home_Type   : int  1 3 1 1 1 3 3 3 3 3 ...
##  $ Ethnic      : int  7 7 7 7 7 7 7 7 7 7 ...
##  $ Language    : int  1 1 1 1 1 1 1 1 1 1 ...
```

```
table(market$Income)
```

```
##
##    1    2    3    4    5    6    7    8    9
## 1255  529  505  618  527  846  784 1069  743
```

```
head(market)
```

```
##   Income Sex Marital Age Edu Occupation Lived Dual_Income Household
## 2      9   1       1   5   5          5     5           3         5
## 3      9   2       1   3   5          1     5           2         3
## 4      1   2       5   1   2          6     5           1         4
## 5      1   2       5   1   2          6     3           1         4
## 6      8   1       1   6   4          8     5           3         2
## 7      1   1       5   2   3          9     4           1         3
##   Householdu18 Status Home_Type Ethnic Language
## 2            2      1         1      7        1
## 3            1      2         3      7        1
## 4            2      3         1      7        1
## 5            2      3         1      7        1
## 6            0      1         1      7        1
## 7            1      2         3      7        1
```

```
set.seed(9850)
gp <- runif(nrow(market))
gp
```

```
##     [1] 0.7495758825 0.9970860172 0.6520019539 0.4329282779 0.3323124126
##     [6] 0.8654064713 0.1793312423 0.4784936542 0.2957953140 0.6644065792
##    [11] 0.7117703257 0.7801193437 0.1356792178 0.0819188494 0.6316598309
##    [16] 0.5296842461 0.0170833713 0.9474428124 0.2882613896 0.0102437572
##    [21] 0.8897227643 0.0998385579 0.9765785441 0.6263110095 0.8189663987
##    [26] 0.8142171314 0.2289382669 0.3933451127 0.9630645688 0.1585229489
##    [31] 0.3653627359 0.8156728500 0.1604756210 0.3250754566 0.9560772402
##    [36] 0.2218299413 0.2403588612 0.6548423267 0.8333722104 0.2233174085
##    [41] 0.5673194607 0.6456432254 0.0465932356 0.1668617709 0.0956007408
##    [46] 0.2807086881 0.2743727185 0.3060213479 0.4662361774 0.7148338449
##    [51] 0.8190107290 0.4139657072 0.0334808941 0.1631714739 0.6145221728
##    [56] 0.6255910993 0.9879692337 0.5909557175 0.2919432321 0.8480136376
##    [61] 0.2396267867 0.2271126616 0.0140372261 0.2352089230 0.3484869979
##    [66] 0.7520098684 0.3978046870 0.1736333375 0.1154108711 0.0966818000
##    [71] 0.7729893238 0.5798524946 0.5923610253 0.3171202319 0.2654884034
##    [76] 0.7360402378 0.7254672160 0.8663905747 0.7741213529 0.0413182371
##    [81] 0.7172160284 0.6180823920 0.0251395968 0.9586153277 0.2370699421
##    [86] 0.1578509451 0.9192689520 0.3734502334 0.6125246426 0.5803679214
##    [91] 0.0404882729 0.6060245500 0.2533204837 0.6174646146 0.6709800093
##    [96] 0.4986784160 0.5396321670 0.6206036371 0.7436010945 0.7073883556
##   [101] 0.8810440945 0.1403651948 0.0095803072 0.6410322264 0.9191053398
##   [106] 0.9689641173 0.1570933873 0.4948440322 0.4536333787 0.2113605556
##   [111] 0.8035114724 0.5228704978 0.5376669175 0.9227446702 0.9753406069
##   [116] 0.2237336703 0.3711161797 0.0353129525 0.3222257327 0.1571450704
##   [121] 0.1685013452 0.0638064316 0.4893020147 0.9682556493 0.4745871460
##   [126] 0.2694554001 0.4516987344 0.2202123308 0.9867946801 0.7751187934
##   [131] 0.6587832973 0.0880496269 0.8152278706 0.7439878148 0.0836194784
##   [136] 0.4659152231 0.7591692442 0.8864776315 0.6038413683 0.1559114396
##   [141] 0.7475329281 0.6899246653 0.9861639573 0.5126079635 0.3113563182
##   [146] 0.6440915293 0.8044008203 0.1331510283 0.7577468259 0.4200751849
##   [151] 0.9882166183 0.5940190239 0.1337920092 0.1093714633 0.4527440837
##   [156] 0.4870031353 0.4772156312 0.6883584394 0.1238144503 0.1765312739
##   [161] 0.0513233980 0.6495025042 0.6077275414 0.5147005529 0.2526203436
##   [166] 0.0743994124 0.0132462864 0.8147595294 0.7346024157 0.9882323125
##   [171] 0.7914368890 0.0421418818 0.4482217485 0.9431283800 0.3041717457
##   [176] 0.3037171357 0.2458586334 0.1390944780 0.9930689118 0.0179640960
##   [181] 0.6333474671 0.3473129433 0.3848697122 0.0925622813 0.3150161311
##   [186] 0.3367951058 0.0606662470 0.8249456959 0.8221009444 0.2811661591
##   [191] 0.9516206449 0.2198111697 0.3371348912 0.4664305942 0.0453822589
##   [196] 0.5599722816 0.3349301305 0.2032854704 0.8286181735 0.6925395546
##   [201] 0.9271206164 0.8221291730 0.9972034085 0.6973466040 0.5169499926
##   [206] 0.5990863321 0.3223969345 0.4964734735 0.4476255970 0.5216260178
##   [211] 0.7556086318 0.3205462527 0.9506412528 0.2985267481 0.0569786283
##   [216] 0.0003940333 0.9927308816 0.7886940781 0.5844371154 0.2674444148
##   [221] 0.3897148769 0.3091349881 0.0609547086 0.7870363081 0.0268985992
##   [226] 0.3048943724 0.1436142863 0.6270551153 0.9310787276 0.1233180955
##   [231] 0.9694899826 0.9042756297 0.4780196615 0.9997890533 0.1102453312
##   [236] 0.8979925164 0.6166725135 0.8766021957 0.4819052627 0.6744408454
##   [241] 0.6150198269 0.5775543137 0.7899192325 0.3725320750 0.1857498381
##   [246] 0.2536579652 0.7994820816 0.0724229221 0.4911580693 0.8653213726
##   [251] 0.7921922009 0.7603564074 0.7658275897 0.2609684896 0.4687628602
##   [256] 0.2254378458 0.8437963750 0.5267864007 0.6994121750 0.2194651333
##   [261] 0.1764618107 0.3986164399 0.2646194524 0.0251766567 0.0470231422
##   [266] 0.1683996238 0.4098842982 0.0107868451 0.4487984118 0.5636629767
##   [271] 0.1780302855 0.0754295127 0.6989828863 0.0783133446 0.5562564055
##   [276] 0.4407939913 0.5425982976 0.2262612802 0.4214579179 0.6611826962
##   [281] 0.7319047865 0.4298188754 0.8704783071 0.3572077535 0.3513338610
##   [286] 0.6648822455 0.7005042701 0.8147210029 0.3996182922 0.4515349315
##   [291] 0.2052623765 0.2991150464 0.7789198267 0.8251774590 0.2134868747
##   [296] 0.5609124941 0.9681383334 0.8594777016 0.9657609260 0.0412506310
##   [301] 0.7548311418 0.4755594810 0.0729731962 0.0331127706 0.5713228611
##   [306] 0.2930599167 0.8516822257 0.1701295599 0.3760239882 0.6877743497
##   [311] 0.9270636514 0.5851917360 0.8916449999 0.9579640331 0.9715138061
##   [316] 0.0018148751 0.9867867955 0.2682508330 0.1255420763 0.6653894021
##   [321] 0.6639811567 0.0419312005 0.6743365913 0.2804404830 0.3287259294
##   [326] 0.2378482595 0.0931047192 0.9018054479 0.1877670337 0.0448879760
##   [331] 0.4912957121 0.7039545635 0.2069241672 0.1909614610 0.5143850462
##   [336] 0.0790889347 0.8782816183 0.9176112625 0.7554454068 0.5667540238
```

```
## [336] 0.0790089347 0.8782810182 0.9170112025 0.7554454008 0.5007540258
## [341] 0.0503111489 0.5667534743 0.6279647511 0.3004350450 0.6171553163
## [346] 0.1975540451 0.6387072350 0.9078744042 0.3736896049 0.1981965557
## [351] 0.8907989997 0.1360701858 0.8814244869 0.2171411105 0.3125700054
## [356] 0.4010509730 0.1826840122 0.5822353936 0.6359907584 0.0989283440
## [361] 0.6765615689 0.1485178072 0.3771007759 0.5530016017 0.3617152253
## [366] 0.1802198892 0.6171681150 0.8206919797 0.6106209494 0.6188949822
## [371] 0.1965838522 0.7399326509 0.4477081764 0.8405267783 0.7720598341
## [376] 0.4463721714 0.2442423559 0.4129812869 0.9434902302 0.4571786132
## [381] 0.3632806947 0.8853263238 0.9804098252 0.2628147874 0.4995117523
## [386] 0.0783771609 0.9786627586 0.7474930072 0.9742306971 0.6519231112
## [391] 0.5787591410 0.8504999247 0.1858147094 0.5311700099 0.3757693039
## [396] 0.0710409759 0.1168735998 0.2629899543 0.0945292274 0.7763616967
## [401] 0.5610128436 0.2645793355 0.6548478331 0.4205896568 0.0012101170
## [406] 0.6909413664 0.4539449201 0.9456541482 0.6482298435 0.1612203491
## [411] 0.3817551841 0.0978815490 0.1326052984 0.7582221008 0.8960668952
## [416] 0.8800401445 0.4565156051 0.4074687117 0.0446191449 0.1227145637
## [421] 0.6949278265 0.7139985876 0.9939945326 0.6775568896 0.2296354824
## [426] 0.3067559281 0.3613714012 0.5828670983 0.8044689302 0.4178014104
## [431] 0.7846563526 0.9693401146 0.5383925089 0.5184600749 0.5122824498
## [436] 0.2567604294 0.0536146075 0.3476216465 0.8644863616 0.3265674536
## [441] 0.9477227284 0.0454477246 0.4449762120 0.1830578083 0.6423300907
## [446] 0.3217225375 0.1303508051 0.5825213124 0.5488352389 0.0627382819
## [451] 0.2106248697 0.0161456941 0.6600540252 0.4429828699 0.1442331073
## [456] 0.4080872475 0.3112419820 0.9642093531 0.5577359174 0.5386357373
## [461] 0.8048723647 0.8766175103 0.9107247747 0.9119267147 0.5844518491
## [466] 0.3036096704 0.6004545721 0.3893659858 0.1694508009 0.5062853550
## [471] 0.8475142985 0.1500015932 0.5692229695 0.6350592151 0.8125925227
## [476] 0.9927694711 0.5778277100 0.1779769494 0.0524727490 0.2861135255
## [481] 0.7531396134 0.5565741351 0.3417827303 0.9198281260 0.3270431000
## [486] 0.2699445796 0.9546168158 0.4164604545 0.9746056078 0.7108827827
## [491] 0.5747230186 0.3832712516 0.7986273118 0.0465102445 0.7782498011
## [496] 0.7288075662 0.3622771099 0.7967084986 0.7859892047 0.3912761284
## [501] 0.2820658600 0.4724560408 0.4979769106 0.5504774062 0.1798995575
## [506] 0.9431819867 0.0173928458 0.2946922968 0.2617952507 0.3866577819
## [511] 0.8236899136 0.9804703973 0.9786893723 0.0874461238 0.2423232968
## [516] 0.4682355982 0.4151789793 0.6408566013 0.7792693924 0.9952017330
## [521] 0.4538622617 0.2369525183 0.0911031228 0.4941899800 0.7573268169
## [526] 0.9759637332 0.8272665150 0.0666006405 0.8550665737 0.7379594685
## [531] 0.2091648474 0.2234360487 0.5748099643 0.0456625621 0.8737061052
## [536] 0.8644837206 0.5649068772 0.1020542879 0.3305484187 0.3831520942
## [541] 0.9865017300 0.5385379894 0.7240771372 0.6195494623 0.9788354205
## [546] 0.9271854351 0.8745491516 0.4269977049 0.3349577596 0.0185232563
## [551] 0.7053462232 0.1822011021 0.1277811474 0.0157198124 0.1998530703
## [556] 0.8981946760 0.5358759942 0.2658297855 0.1271681262 0.6364200653
## [561] 0.2786050050 0.0234654092 0.0119031209 0.6523088077 0.8982881957
## [566] 0.4078337569 0.7285185391 0.5301294886 0.1780489252 0.1035953860
## [571] 0.1922239508 0.1034923417 0.3384429773 0.9716999596 0.8468415199
## [576] 0.1052702949 0.1234927864 0.9305821322 0.1196248806 0.3039521575
## [581] 0.2435623566 0.0137212882 0.6620927702 0.3497284127 0.5567536722
## [586] 0.7529810946 0.9893552961 0.1243141179 0.5165801493 0.9586648750
## [591] 0.0718291770 0.1833264511 0.8320446324 0.4665242680 0.2699698750
## [596] 0.9715187086 0.3100580734 0.9035872051 0.7182190758 0.3333162433
## [601] 0.7150674043 0.9340615487 0.3674025910 0.7596312065 0.6479979081
## [606] 0.7328381760 0.7132479607 0.4942491085 0.4307066249 0.0745273684
## [611] 0.3548775504 0.7125458966 0.3533411089 0.6661907502 0.3784803569
## [616] 0.3429163655 0.2376556913 0.4553024529 0.6146818218 0.9231636936
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## [6876] 0.7841512996
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market <- market[order(gp),]
summary(market)
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##      Income          Sex          Marital          Age
##  Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000
##  1st Qu.:2.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:2.000
##  Median :6.000   Median :2.000   Median :3.000   Median :3.000
##  Mean   :5.052   Mean   :1.554   Mean   :2.998   Mean   :3.408
##  3rd Qu.:8.000   3rd Qu.:2.000   3rd Qu.:5.000   3rd Qu.:4.000
##  Max.   :9.000   Max.   :2.000   Max.   :5.000   Max.   :7.000
##       Edu          Occupation        Lived        Dual_Income       Household
##  Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.00   Min.   :1.000
##  1st Qu.:3.000   1st Qu.:1.000   1st Qu.:4.000   1st Qu.:1.00   1st Qu.:2.000
##  Median :4.000   Median :3.000   Median :5.000   Median :1.00   Median :3.000
##  Mean   :3.893   Mean   :3.639   Mean   :4.213   Mean   :1.55   Mean   :2.861
##  3rd Qu.:5.000   3rd Qu.:6.000   3rd Qu.:5.000   3rd Qu.:2.00   3rd Qu.:4.000
##  Max.   :6.000   Max.   :9.000   Max.   :5.000   Max.   :3.00   Max.   :9.000
##   Householdu18        Status        Home_Type        Ethnic
##  Min.   :0.0000   Min.   :1.000   Min.   :1.00   Min.   :1.000
##  1st Qu.:0.0000   1st Qu.:1.000   1st Qu.:1.00   1st Qu.:5.000
##  Median :0.0000   Median :2.000   Median :1.00   Median :7.000
##  Mean   :0.6869   Mean   :1.829   Mean   :1.82   Mean   :6.013
##  3rd Qu.:1.0000   3rd Qu.:2.000   3rd Qu.:3.00   3rd Qu.:7.000
##  Max.   :9.0000   Max.   :3.000   Max.   :5.00   Max.   :8.000
##     Language
##  Min.   :1.000
##  1st Qu.:1.000
##  Median :1.000
##  Mean   :1.116
##  3rd Qu.:1.000
##  Max.   :3.000
```

```r
normalise <- function(x) { + return ( ( x - min(x)) / ( max(x) - min(x))) }
market_n <- as.data.frame(lapply(market[,c(1,2,3,4)], normalise))
summary(market_n)
```

```
##      Income          Sex          Marital          Age
##  Min.   :0.0000   Min.   :0.000   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.1250   1st Qu.:0.000   1st Qu.:0.0000   1st Qu.:0.1667
##  Median :0.6250   Median :1.000   Median :0.5000   Median :0.3333
##  Mean   :0.5065   Mean   :0.554   Mean   :0.4996   Mean   :0.4013
##  3rd Qu.:0.8750   3rd Qu.:1.000   3rd Qu.:1.0000   3rd Qu.:0.5000
##  Max.   :1.0000   Max.   :1.000   Max.   :1.0000   Max.   :1.0000
```

```r
market_train <- market_n[1:6000, ]
market_test  <- market_n[6001:6876, ]
market_train_target <- market[1:6000, 5]
market_test_target <- market[6001:6876, 5]
require(class)
```

```
## Loading required package: class
```

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

```r
m1 <- knn(train=market_train, test=market_test, cl=market_train_target, k=83)
m1
```

```
##   [1] 5 3 4 4 4 4 4 4 4 4 5 3 2 6 4 4 2 4 4 4 2 4 4 4 2 3 2 4 4 4 4 4 4 4 4 3 4
##  [38] 4 5 4 2 3 4 4 4 4 2 2 5 4 4 4 5 4 6 2 4 4 4 6 2 4 3 6 4 4 5 4 4 4 4 4 4 6
##  [75] 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 5 4 4 4 5 4 6 4 4 4 4 3 4 4 2 2 4 6 5 4 6
## [112] 4 4 3 3 6 4 4 4 4 3 4 5 4 4 3 2 4 3 4 3 4 4 4 4 4 2 4 4 3 6 6 4 3 4 4 4 4
## [149] 4 4 4 4 4 4 4 4 4 4 4 4 5 4 4 4 4 2 4 4 4 4 4 4 4 4 2 4 4 4 4 4 4 3 4 4 4 4
## [186] 4 3 2 4 4 4 4 4 4 5 4 4 4 4 4 4 4 4 4 4 4 4 2 4 4 3 6 4 4 4 3 4 4 4 4 4 4 6
## [223] 4 4 4 4 4 2 4 3 4 2 4 4 4 4 5 4 6 4 4 4 3 4 4 4 4 4 4 4 4 4 4 2 4 4 4 4 4 4
## [260] 5 3 4 4 4 4 4 2 4 4 4 6 4 2 4 4 4 2 4 4 4 4 2 4 4 4 3 3 6 4 4 4 4 2 4 4 4
## [297] 4 4 4 4 4 4 4 2 4 4 3 5 5 4 4 4 4 4 2 4 4 4 6 5 4 4 5 4 4 4 3 4 4 4 4 4 4
## [334] 4 4 3 4 4 4 4 4 3 4 4 4 4 4 4 4 4 6 4 4 4 2 4 4 4 4 4 4 4 4 4 4 4 4 3 4 4 4
## [371] 4 2 4 4 4 4 4 4 4 4 5 4 4 3 4 4 4 4 4 4 4 4 4 4 4 4 5 2 4 2 4 4 4 4 4 3 4 4
## [408] 5 4 3 2 4 4 3 4 4 4 4 4 4 4 6 6 6 4 3 4 5 3 5 4 4 4 6 2 2 4 4 4 4 4 3 4 2
## [445] 4 4 4 4 4 4 4 4 4 6 4 4 4 3 4 4 4 4 4 4 4 3 4 4 4 4 4 5 3 4 2 3 4 2 4 4 4
## [482] 4 2 4 4 2 4 4 4 4 2 4 4 4 4 4 2 4 4 2 5 4 4 4 4 4 4 4 3 4 4 4 4 2 2 4 4 5
## [519] 4 4 4 4 2 4 4 4 4 2 4 4 4 4 3 2 2 4 4 4 4 4 4 4 4 4 4 4 4 4 2 4 5 4 4 3 4
## [556] 4 6 4 4 4 3 3 3 6 6 5 2 4 5 4 4 2 4 4 4 4 4 4 5 4 4 4 4 4 4 4 3 4 4 6 5 5
## [593] 4 4 4 4 4 2 4 4 5 4 6 4 3 2 2 4 4 4 2 4 4 2 6 4 5 4 4 4 4 4 4 6 4 4 2 4
## [630] 4 4 6 4 4 4 4 4 4 4 4 4 4 5 4 4 4 4 4 3 5 3 5 6 4 4 3 4 2 2 4 5 4 3 3 5
## [667] 4 2 4 5 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 3 4 5 4 4 4 4 5 2 4 4 4 4 6 4 2 6 3
## [704] 4 4 4 4 4 4 4 6 4 2 4 4 4 6 3 4 5 4 2 4 4 4 4 5 4 4 4 4 4 4 4 4 4 4 4 4 2
## [741] 4 2 4 4 4 3 4 4 4 4 4 4 5 3 4 4 4 3 4 4 4 4 4 4 2 5 5 4 4 5 4 4 4 6 4 2 4
## [778] 4 4 2 6 4 4 4 4 5 4 4 4 4 4 4 4 4 4 4 4 4 4 3 3 4 2 4 4 4 4 4 5 4 4 4 4 3 4
## [815] 4 2 4 4 4 4 4 4 3 2 4 4 6 4 4 4 4 4 4 4 4 4 4 5 3 4 4 4 4 4 4 4 4 4 4 6 3
## [852] 4 4 4 4 2 4 2 4 4 4 4 2 4 4 4 4 4 3 4 2 5 5 4 4 4
## Levels: 1 2 3 4 5 6
```

```
table(market_test_target, m1)
```

```
##                  m1
## market_test_target   1   2   3   4   5   6
##                1   0  15   3   6   0   0
##                2   0  59   9  39   1   0
##                3   0   3  21 143   3   0
##                4   0   0  17 249  14   5
##                5   0   0  10 131  23  13
##                6   0   0   6  72  12  22
```

```r
#Bootstrap
library(boot)
alpha.fn=function(data,index){
  X=data$Occupation[index]
  Y=data$Income[index]
  return((var(Y)-cov(X,Y))/(var(X)+var(Y)-2*cov(X,Y)))}
alpha.fn(market,1:6876)
```

```
## [1] 0.5368792
```

```r
set.seed(1)
alpha.fn(market,sample(6876,6876,replace=T))
```

```
## [1] 0.5307537
```

```r
boot(market,alpha.fn,R=1000)
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = market, statistic = alpha.fn, R = 1000)
##
##
## Bootstrap Statistics :
##     original       bias    std. error
## t1* 0.5368792 8.615137e-05  0.00259359
```

```
boot.fn=function(data,index)
  return(coef(lm(Income~Occupation,data=data,subset=index)))
boot.fn(market,1:6876)
```

```
## (Intercept)   Occupation
##   6.5100322  -0.4006307
```

```
set.seed(1)
boot.fn(market,sample(6876,6876,replace=T))
```

```
## (Intercept)   Occupation
##   6.4375695  -0.3741181
```

```
boot.fn(market,sample(6876,6876,replace=T))
```

```
## (Intercept)   Occupation
##   6.4171549  -0.3768462
```

```
boot(market,boot.fn,1000)
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = market, statistic = boot.fn, R = 1000)
##
##
## Bootstrap Statistics :
##       original          bias     std. error
## t1*   6.5100322  0.0015404034  0.04686806
## t2* -0.4006307 -0.0006051708  0.01252589
```

```
summary(lm(Income~Occupation,data=market))$coef
```

```
##              Estimate Std. Error    t value      Pr(>|t|)
## (Intercept)  6.5100322 0.05495855 118.45350  0.000000e+00
## Occupation  -0.4006307 0.01243292 -32.22339 2.739738e-212
```

```
boot.fn=function(data,index)
  coefficients(lm(Income~Occupation+I(Occupation^2),data=data,subset=index))
set.seed(1)
boot(market,boot.fn,1000)
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = market, statistic = boot.fn, R = 1000)
##
##
## Bootstrap Statistics :
##       original          bias     std. error
## t1*   7.57692944   0.0024115414 0.075450250
## t2* -1.19450353  -0.0017875989 0.049812491
## t3*   0.09325227   0.0001708635 0.005794576
```

```
summary(lm(Income~Occupation+I(Occupation^2),data=market))$coef
```

```
##                  Estimate  Std. Error   t value      Pr(>|t|)
## (Intercept)      7.57692944 0.083095506  91.18338  0.000000e+00
## Occupation      -1.19450353 0.048635036 -24.56056 9.419339e-128
## I(Occupation^2)  0.09325227 0.005530727  16.86076  1.559983e-62
```

```
#Best Subset
sum(is.na(marketing$Income))
```

```
## [1] 0
```

```
marketing=na.omit(marketing)
dim(marketing)
```

```
## [1] 6876    14
```

```
sum(is.na(marketing))
```

```
## [1] 0
```

```
library(leaps)
```

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

```
regfit.full=regsubsets(Income~.,marketing)
summary(regfit.full)
```

```
## Subset selection object
## Call: regsubsets.formula(Income ~ ., marketing)
## 13 Variables  (and intercept)
##              Forced in Forced out
## Sex              FALSE     FALSE
## Marital          FALSE     FALSE
## Age              FALSE     FALSE
## Edu              FALSE     FALSE
## Occupation       FALSE     FALSE
## Lived            FALSE     FALSE
## Dual_Income      FALSE     FALSE
## Household        FALSE     FALSE
## Householdu18     FALSE     FALSE
## Status           FALSE     FALSE
## Home_Type        FALSE     FALSE
## Ethnic           FALSE     FALSE
## Language         FALSE     FALSE
## 1 subsets of each size up to 8
## Selection Algorithm: exhaustive
##          Sex Marital Age Edu Occupation Lived Dual_Income Household
## 1  ( 1 ) " " " "     " " " " " "        " "   " "         " "
## 2  ( 1 ) " " " "     "*" " " "*" " "     " "   " "         " "
## 3  ( 1 ) " " " "     "*" " " "*" "*"     " "   " "         " "
## 4  ( 1 ) " " " "     "*" " " "*" "*"     " "   " "         " "
## 5  ( 1 ) " " " "     "*" " " "*" "*"     " "   " "         " "
## 6  ( 1 ) "*" "*"     " " " " "*" "*"     " "   " "         " "
## 7  ( 1 ) "*" "*"     "*" "*" "*"        " "   " "         " "
## 8  ( 1 ) "*" "*"     "*" "*" "*"        " "   " "         "*"
##          Householdu18 Status Home_Type Ethnic Language
## 1  ( 1 ) " "          "*"    " "       " "    " "
## 2  ( 1 ) " "          " "    " "       " "    " "
## 3  ( 1 ) " "          " "    " "       " "    " "
## 4  ( 1 ) " "          "*"    " "       " "    " "
## 5  ( 1 ) " "          "*"    "*"       " "    " "
## 6  ( 1 ) " "          "*"    "*"       " "    " "
## 7  ( 1 ) " "          "*"    "*"       " "    " "
## 8  ( 1 ) " "          "*"    "*"       " "    " "
```
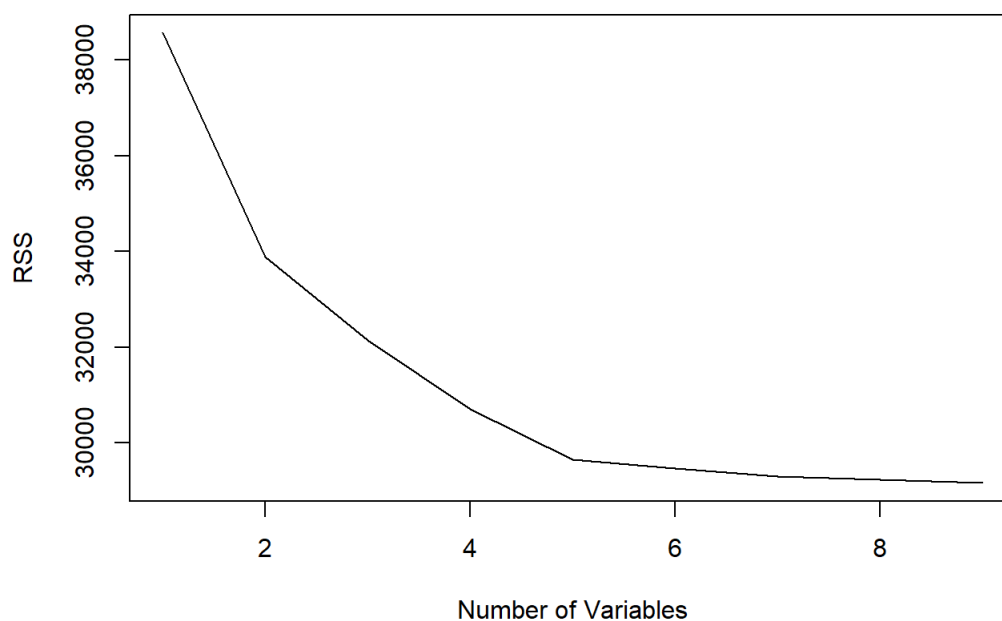
```
regfit.full=regsubsets(Income~.,data=marketing,nvmax=9)
reg.summary=summary(regfit.full)
names(reg.summary)
```

```
## [1] "which"  "rsq"    "rss"    "adjr2"  "cp"     "bic"    "outmat" "obj"
```

```
reg.summary$rsq
```

```
## [1] 0.2716429 0.3600871 0.3929500 0.4202426 0.4400400 0.4436184 0.4467084
## [8] 0.4479513 0.4492489
```
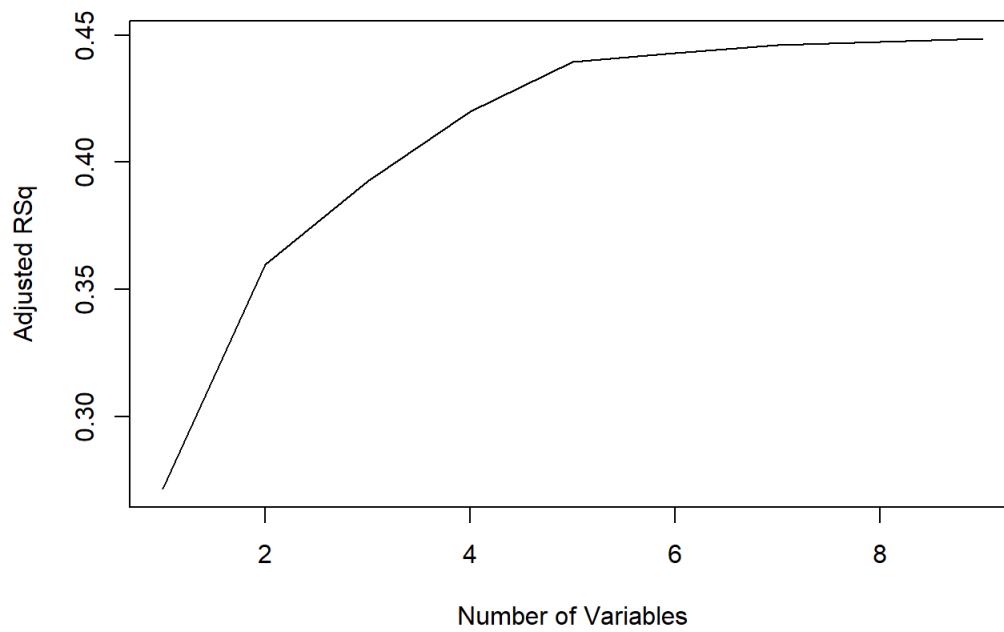
```
par(mfrow=c(1,1))
plot(reg.summary$rss,xlab="Number of Variables",ylab="RSS",type="l")
```



```
plot(reg.summary$adjr2,xlab="Number of Variables",ylab="Adjusted RSq",type="l")
which.max(reg.summary$adjr2)
```

```
## [1] 9
```

```
points(11,reg.summary$adjr2[11], col="red",cex=2,pch=20)
```

```
plot(reg.summary$cp,xlab="Number of Variables",ylab="Cp",type='l')
which.min(reg.summary$cp)
```

```
## [1] 9
```

```
points(10,reg.summary$cp[10],col="red",cex=2,pch=20)
```
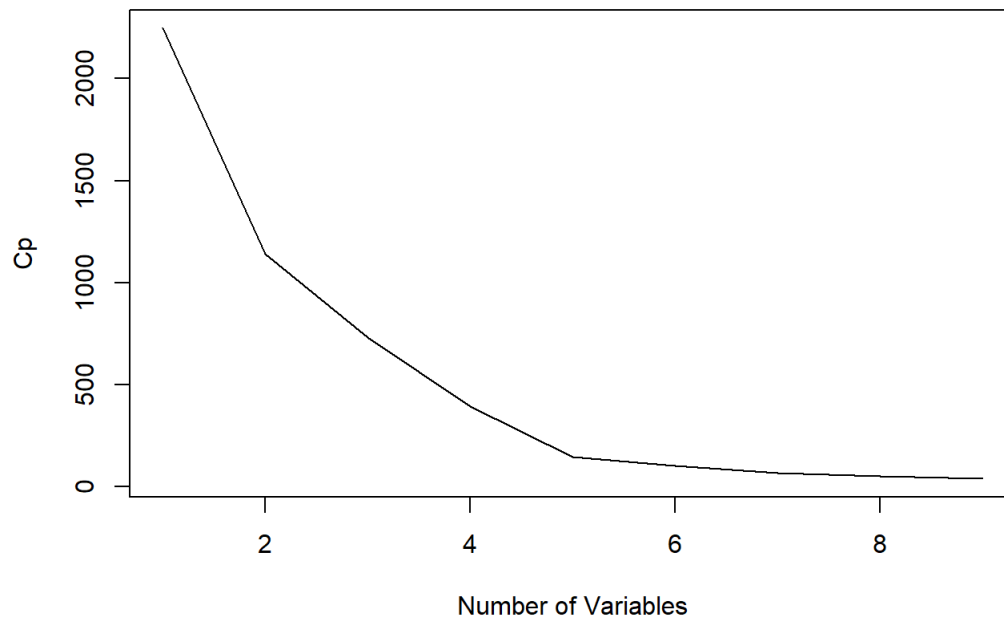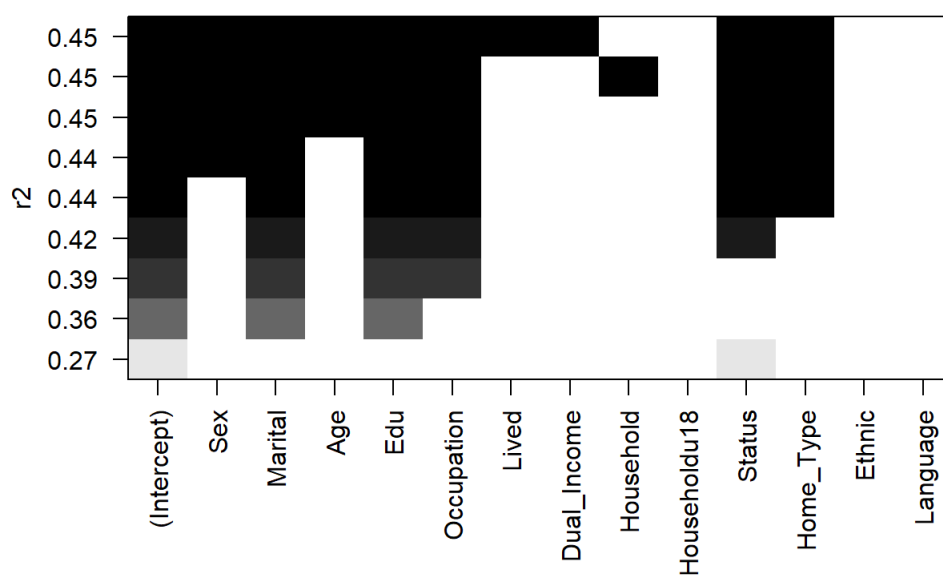


```
which.min(reg.summary$bic)
```
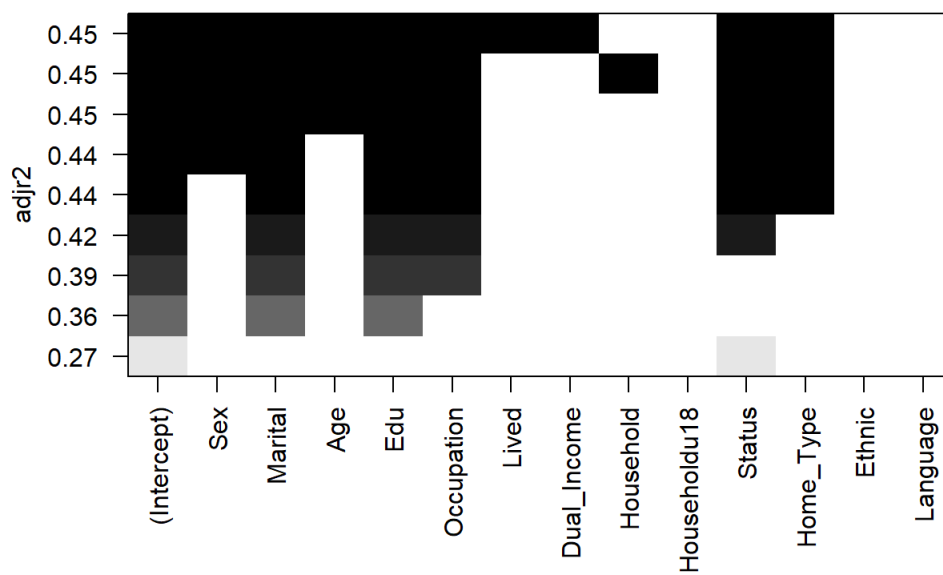
```
## [1] 9
```

```
plot(reg.summary$bic,xlab="Number of Variables",ylab="BIC",type='l')
points(6,reg.summary$bic[6],col="red",cex=2,pch=20)
```
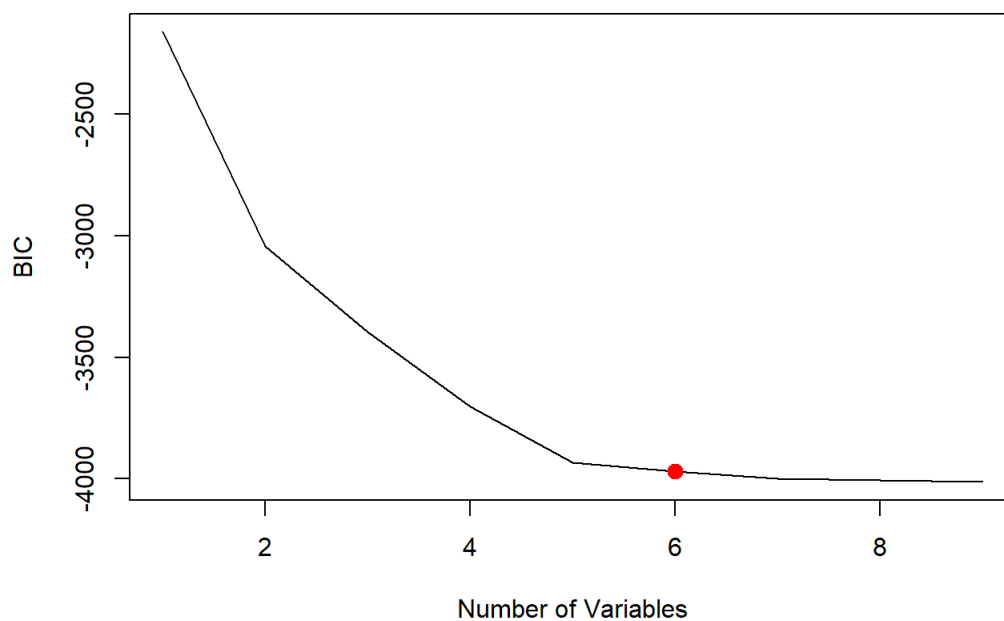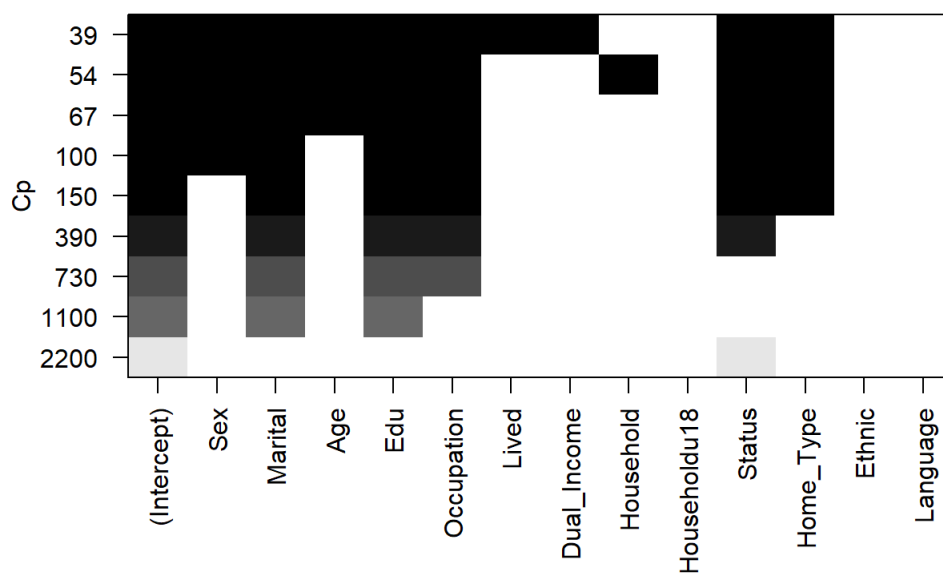
```
plot(regfit.full,scale="r2")
```
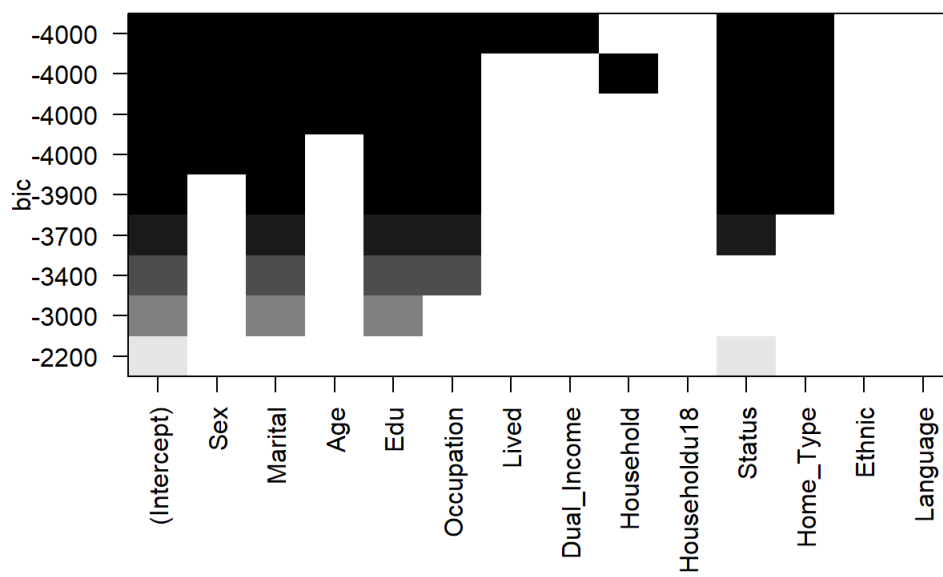


```
plot(regfit.full,scale="adjr2")
```

```
plot(regfit.full,scale="Cp")
```



```
plot(regfit.full,scale="bic")
```

```
coef(regfit.full,6)
```

```
## (Intercept)          Sex       Marital          Edu   Occupation       Status
##    7.5598739   -0.3371087   -0.4026584    0.5230016   -0.2099638   -0.7645637
##     Home_Type
##   -0.3571643
```