Data Processing Assignment

Gaelan Gu, Sunil Prakash, Wang Ruoshi, Yu Yue

Introduction

We will be preparing the salary dataset, extracted from the 1994 US Census, for a logistic regression.

We will determine whether a person makes over 50k a year; *class* will be the dependent variable.

Data Import

```
train = read.csv('salary-train.csv')
test = read.csv('salary-test.csv')
str(train)
```

```
## 'data.frame':    32561 obs. of  14 variables:
##  $ age           : int  39 50 38 53 28 37 49 52 31 42 ...
##  $ workclass     : Factor w/ 9 levels " ?"," Federal-gov",..: 8 7 5 5 5 5
5 7 5 5 ...
##  $ fnlwgt        : int  77516 83311 215646 234721 338409 284582 160187 209
642 45781 159449 ...
##  $ education     : Factor w/ 16 levels " 10th"," 11th",..: 10 10 12 2 10 1
3 7 12 13 10 ...
##  $ marital       : Factor w/ 7 levels " Divorced"," Married-AF-spouse",..:
5 3 1 3 3 3 4 3 5 3 ...
##  $ occupation    : Factor w/ 15 levels " ?"," Adm-clerical",..: 2 5 7 7 11
5 9 5 11 5 ...
##  $ relationship  : Factor w/ 6 levels " Husband"," Not-in-family",..: 2 1
2 1 6 6 2 1 2 1 ...
##  $ race          : Factor w/ 5 levels " Amer-Indian-Eskimo",..: 5 5 5 3 3
5 3 5 5 5 ...
##  $ sex           : Factor w/ 2 levels " Female"," Male": 2 2 2 2 1 1 1 2 1
2 ...
##  $ capital.gain  : int  2174 0 0 0 0 0 0 0 14084 5178 ...
##  $ capital.loss  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ hours.per.week: int  40 13 40 40 40 40 16 45 50 40 ...
##  $ native.country: Factor w/ 42 levels " ?"," Cambodia",..: 40 40 40 40 6
40 24 40 40 40 ...
##  $ class         : Factor w/ 2 levels " <=50K"," >50K": 1 1 1 1 1 1 1 2 2
2 ...
```

```
str(test)
```

```
## 'data.frame':    16281 obs. of  14 variables:
##  $ age           : int  25 38 28 44 18 34 29 63 24 55 ...
##  $ workclass     : Factor w/ 9 levels " ?"," Federal-gov",..: 5 5 3 5 1 5
```

```
1 7 5 5 ...
##  $ fnlwgt        : int  226802 89814 336951 160323 103497 198693 227026 10
4626 369667 104996 ...
##  $ education     : Factor w/ 16 levels " 10th"," 11th",..: 2 12 8 16 16 1
12 15 16 6 ...
##  $ marital       : Factor w/ 7 levels " Divorced"," Married-AF-spouse",..:
5 3 3 3 5 5 5 3 5 3 ...
##  $ occupation    : Factor w/ 15 levels " ?"," Adm-clerical",..: 8 6 12 8 1
9 1 11 9 4 ...
##  $ relationship  : Factor w/ 6 levels " Husband"," Not-in-family",..: 4 1
1 1 4 2 5 1 5 1 ...
##  $ race          : Factor w/ 5 levels " Amer-Indian-Eskimo",..: 3 5 5 3 5
5 3 5 5 5 ...
##  $ sex           : Factor w/ 2 levels " Female"," Male": 2 2 2 2 1 2 2 2 1
2 ...
##  $ capital.gain  : int  0 0 0 7688 0 0 0 3103 0 0 ...
##  $ capital.loss  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ hours.per.week: int  40 50 40 40 30 30 40 32 40 10 ...
##  $ native.country: Factor w/ 41 levels " ?"," Cambodia",..: 39 39 39 39 39
39 39 39 39 39 ...
##  $ class         : Factor w/ 2 levels " <=50K."," >50K.": 1 1 2 2 1 1 1 2
1 1 ...
```

We first import our datasets and determine which columns contain missing values.

From a glance, we can tell that the *workclass*, *occupation* and *native.country* columns contain missing values, indicated by question marks.

Setting Entries with Question Marks as NA Values

```
# train set
train$workclass = as.factor(gsub('?', NA, train$workclass, fixed = T))
train$native.country = as.factor(gsub('?', NA, train$native.country, fixed =
T))
train$occupation = as.factor(gsub('?', NA, train$occupation, fixed = T))

# test set
test$workclass = as.factor(gsub('?', NA, test$workclass, fixed = T))
test$native.country = as.factor(gsub('?', NA, test$native.country, fixed = T)
)
test$occupation = as.factor(gsub('?', NA, test$occupation, fixed = T))
```

Since the missing values exist in both the training and testing datasets, therefore we have to indicate them as NA values before we may exclude them.

Removing Incomplete Cases

```
train = train[complete.cases(train), ]
test = test[complete.cases(test), ]
str(train)
```

```
## 'data.frame':	30162 obs. of  14 variables:
##  $ age           : int  39 50 38 53 28 37 49 52 31 42 ...
##  $ workclass     : Factor w/ 8 levels " Federal-gov",..: 7 6 4 4 4 4 4 6 4 
4 ...
##  $ fnlwgt        : int  77516 83311 215646 234721 338409 284582 160187 209
642 45781 159449 ...
##  $ education     : Factor w/ 16 levels " 10th"," 11th",..: 10 10 12 2 10 1
3 7 12 13 10 ...
##  $ marital       : Factor w/ 7 levels " Divorced"," Married-AF-spouse",..: 
5 3 1 3 3 3 4 3 5 3 ...
##  $ occupation    : Factor w/ 14 levels " Adm-clerical",..: 1 4 6 6 10 4 8 
4 10 4 ...
##  $ relationship  : Factor w/ 6 levels " Husband"," Not-in-family",..: 2 1 
2 1 6 6 2 1 2 1 ...
##  $ race          : Factor w/ 5 levels " Amer-Indian-Eskimo",..: 5 5 5 3 3 
5 3 5 5 5 ...
##  $ sex           : Factor w/ 2 levels " Female"," Male": 2 2 2 2 1 1 1 2 1 
2 ...
##  $ capital.gain  : int  2174 0 0 0 0 0 0 0 14084 5178 ...
##  $ capital.loss  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ hours.per.week: int  40 13 40 40 40 40 16 45 50 40 ...
##  $ native.country: Factor w/ 41 levels " Cambodia"," Canada",..: 39 39 39 
39 5 39 23 39 39 39 ...
##  $ class         : Factor w/ 2 levels " <=50K"," >50K": 1 1 1 1 1 1 1 2 2 
2 ...
```

```r
str(test)
```

```
## 'data.frame':	15060 obs. of  14 variables:
##  $ age           : int  25 38 28 44 34 63 24 55 65 36 ...
##  $ workclass     : Factor w/ 8 levels " Federal-gov",..: 4 4 2 4 4 6 4 4 4 
1 ...
##  $ fnlwgt        : int  226802 89814 336951 160323 198693 104626 369667 10
4996 184454 212465 ...
##  $ education     : Factor w/ 16 levels " 10th"," 11th",..: 2 12 8 16 1 15 
16 6 12 10 ...
##  $ marital       : Factor w/ 7 levels " Divorced"," Married-AF-spouse",..: 
5 3 3 3 5 3 5 3 3 3 ...
##  $ occupation    : Factor w/ 14 levels " Adm-clerical",..: 7 5 11 7 8 10 8 
3 7 1 ...
##  $ relationship  : Factor w/ 6 levels " Husband"," Not-in-family",..: 4 1 
1 1 2 1 5 1 1 1 ...
##  $ race          : Factor w/ 5 levels " Amer-Indian-Eskimo",..: 3 5 5 3 5 
5 5 5 5 5 ...
##  $ sex           : Factor w/ 2 levels " Female"," Male": 2 2 2 2 2 2 1 2 2 
2 ...
##  $ capital.gain  : int  0 0 0 7688 0 3103 0 0 6418 0 ...
##  $ capital.loss  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ hours.per.week: int  40 50 40 40 30 32 40 10 40 40 ...
##  $ native.country: Factor w/ 40 levels " Cambodia"," Canada",..: 38 38 38 
```

```
38 38 38 38 38 38 38 ...
##  $ class         : Factor w/ 2 levels " <=50K."," >50K.": 1 1 2 2 1 2 1 1
2 1 ...
```

We run the *complete.cases* function to remove the NA values from both datasets. After that we use the *str* function again to ascertain that the variables are in the formats we need, without anymore missing entries.

Full Model

```
fit = suppressWarnings(glm(formula = class ~ .,
          family = binomial,
          data = train))
```

We start to train our training set using a logistic classifier, with *class* as our target variable. We use the rest of the variables as input.

Prediction the Test Set Results

```
prob_pred = predict(fit, type = 'response', newdata = test[-14])
y_pred = ifelse(prob_pred > 0.5, '>50K', '<=50K')

# Confusion Matrix
cm = table(test[, 14], y_pred)
cm

##            y_pred
##             <=50K  >50K
##    <=50K. 10530   830
##    >50K.   1465  2235
```

Computing the Accuracy and Error Rates

```
acc = sum(diag(cm)) / sum(cm)
acc

## [1] 0.8476096

err = 1 - acc
err

## [1] 0.1523904
```

Model has a **84.76%** accuracy rate / **15.24%** error rate.

Let us see if we can improve the error rate through feature selection.

```
summary(fit)

##
## Call:
## glm(formula = class ~ ., family = binomial, data = train)
##
## Deviance Residuals:
```

```
##     Min       1Q   Median       3Q      Max
## -5.1182  -0.5148  -0.1885   0.0000   3.7839
##
## Coefficients:
##                                            Estimate Std. Error z value
## (Intercept)                              -6.408e+00  7.636e-01  -8.392
## age                                       2.550e-02  1.712e-03  14.890
## workclass Local-gov                      -6.985e-01  1.130e-01  -6.184
## workclass Private                        -5.055e-01  9.379e-02  -5.390
## workclass Self-emp-inc                   -3.293e-01  1.239e-01  -2.658
## workclass Self-emp-not-inc               -9.972e-01  1.100e-01  -9.063
## workclass State-gov                      -8.207e-01  1.254e-01  -6.544
## workclass Without-pay                    -1.329e+01  1.972e+02  -0.067
## fnlwgt                                    7.515e-07  1.762e-07   4.264
## education 11th                            9.462e-02  2.139e-01   0.442
## education 12th                            4.443e-01  2.784e-01   1.596
## education 1st-4th                        -4.398e-01  4.960e-01  -0.887
## education 5th-6th                        -3.956e-01  3.590e-01  -1.102
## education 7th-8th                        -5.640e-01  2.433e-01  -2.318
## education 9th                            -2.372e-01  2.702e-01  -0.878
## education Assoc-acdm                      1.269e+00  1.797e-01   7.063
## education Assoc-voc                       1.268e+00  1.729e-01   7.332
## education Bachelors                       1.899e+00  1.608e-01  11.807
## education Doctorate                       2.935e+00  2.231e-01  13.159
## education HS-grad                         7.735e-01  1.564e-01   4.945
## education Masters                         2.259e+00  1.719e-01  13.138
## education Preschool                      -2.008e+01  1.987e+02  -0.101
## education Prof-school                     2.844e+00  2.071e-01  13.734
## education Some-college                    1.109e+00  1.587e-01   6.989
## marital Married-AF-spouse                 2.768e+00  5.766e-01   4.800
## marital Married-civ-spouse                2.105e+00  2.747e-01   7.663
## marital Married-spouse-absent             1.220e-02  2.404e-01   0.051
## marital Never-married                    -4.861e-01  8.926e-02  -5.446
## marital Separated                        -8.940e-02  1.656e-01  -0.540
## marital Widowed                           1.852e-01  1.582e-01   1.171
## occupation Armed-Forces                  -1.165e+00  1.547e+00  -0.753
## occupation Craft-repair                   6.369e-02  8.076e-02   0.789
## occupation Exec-managerial                8.054e-01  7.794e-02  10.334
## occupation Farming-fishing               -9.809e-01  1.408e-01  -6.968
## occupation Handlers-cleaners             -6.950e-01  1.447e-01  -4.803
## occupation Machine-op-inspct             -2.633e-01  1.027e-01  -2.564
## occupation Other-service                 -8.245e-01  1.191e-01  -6.920
## occupation Priv-house-serv               -4.153e+00  1.723e+00  -2.411
## occupation Prof-specialty                 5.165e-01  8.253e-02   6.259
## occupation Protective-serv                5.978e-01  1.263e-01   4.734
## occupation Sales                          2.943e-01  8.318e-02   3.538
## occupation Tech-support                   6.648e-01  1.117e-01   5.951
## occupation Transport-moving              -8.982e-02  1.001e-01  -0.898
## relationship Not-in-family                4.522e-01  2.716e-01   1.665
## relationship Other-relative              -3.960e-01  2.477e-01  -1.599
```

```
## relationship Own-child                     -7.322e-01  2.706e-01  -2.706
## relationship Unmarried                      3.358e-01  2.873e-01   1.169
## relationship Wife                           1.351e+00  1.057e-01  12.784
## race Asian-Pac-Islander                     8.280e-01  2.860e-01   2.896
## race Black                                  4.359e-01  2.409e-01   1.810
## race Other                                  1.255e-01  3.786e-01   0.332
## race White                                  5.875e-01  2.291e-01   2.564
## sex Male                                    8.648e-01  8.091e-02  10.689
## capital.gain                                3.225e-04  1.074e-05  30.022
## capital.loss                                6.420e-04  3.845e-05  16.696
## hours.per.week                              2.949e-02  1.702e-03  17.325
## native.country Canada                      -8.113e-01  6.890e-01  -1.178
## native.country China                       -1.916e+00  7.031e-01  -2.725
## native.country Columbia                    -3.275e+00  1.031e+00  -3.177
## native.country Cuba                        -7.738e-01  7.028e-01  -1.101
## native.country Dominican-Republic          -2.915e+00  1.220e+00  -2.390
## native.country Ecuador                     -1.400e+00  9.587e-01  -1.461
## native.country El-Salvador                 -1.745e+00  7.922e-01  -2.203
## native.country England                     -8.348e-01  7.004e-01  -1.192
## native.country France                      -5.604e-01  8.137e-01  -0.689
## native.country Germany                     -6.860e-01  6.781e-01  -1.012
## native.country Greece                      -2.126e+00  8.369e-01  -2.540
## native.country Guatemala                   -1.396e+00  9.798e-01  -1.424
## native.country Haiti                       -1.169e+00  9.273e-01  -1.261
## native.country Holand-Netherlands          -1.164e+01  8.827e+02  -0.013
## native.country Honduras                    -2.306e+00  2.607e+00  -0.885
## native.country Hong                        -1.355e+00  9.005e-01  -1.505
## native.country Hungary                     -1.254e+00  9.905e-01  -1.266
## native.country India                       -1.664e+00  6.682e-01  -2.491
## native.country Iran                        -1.123e+00  7.578e-01  -1.482
## native.country Ireland                     -6.158e-01  8.884e-01  -0.693
## native.country Italy                       -3.295e-01  7.089e-01  -0.465
## native.country Jamaica                     -1.125e+00  7.708e-01  -1.460
## native.country Japan                       -9.413e-01  7.294e-01  -1.290
## native.country Laos                        -1.883e+00  1.046e+00  -1.801
## native.country Mexico                      -1.649e+00  6.648e-01  -2.481
## native.country Nicaragua                   -1.880e+00  1.020e+00  -1.843
## native.country Outlying-US(Guam-USVI-etc) -1.342e+01  2.095e+02  -0.064
## native.country Peru                        -1.985e+00  1.053e+00  -1.884
## native.country Philippines                 -8.782e-01  6.441e-01  -1.363
## native.country Poland                      -1.146e+00  7.455e-01  -1.537
## native.country Portugal                    -1.122e+00  8.849e-01  -1.268
## native.country Puerto-Rico                 -1.440e+00  7.381e-01  -1.950
## native.country Scotland                    -1.407e+00  1.085e+00  -1.297
## native.country South                       -2.446e+00  7.356e-01  -3.325
## native.country Taiwan                      -1.384e+00  7.540e-01  -1.835
## native.country Thailand                    -1.831e+00  1.017e+00  -1.800
## native.country Trinadad&Tobago             -1.580e+00  1.060e+00  -1.490
## native.country United-States               -9.549e-01  6.302e-01  -1.515
## native.country Vietnam                     -2.395e+00  8.452e-01  -2.834
```

```
## native.country Yugoslavia                  -4.609e-01  9.193e-01  -0.501
##                                             Pr(>|z|)
## (Intercept)                                  < 2e-16 ***
## age                                          < 2e-16 ***
## workclass Local-gov                         6.26e-10 ***
## workclass Private                           7.06e-08 ***
## workclass Self-emp-inc                      0.007857 **
## workclass Self-emp-not-inc                   < 2e-16 ***
## workclass State-gov                         6.00e-11 ***
## workclass Without-pay                       0.946265
## fnlwgt                                      2.01e-05 ***
## education 11th                              0.658185
## education 12th                              0.110525
## education 1st-4th                           0.375228
## education 5th-6th                           0.270456
## education 7th-8th                           0.020461 *
## education 9th                               0.379942
## education Assoc-acdm                        1.63e-12 ***
## education Assoc-voc                         2.27e-13 ***
## education Bachelors                          < 2e-16 ***
## education Doctorate                          < 2e-16 ***
## education HS-grad                           7.61e-07 ***
## education Masters                            < 2e-16 ***
## education Preschool                         0.919495
## education Prof-school                        < 2e-16 ***
## education Some-college                      2.76e-12 ***
## marital Married-AF-spouse                   1.59e-06 ***
## marital Married-civ-spouse                  1.82e-14 ***
## marital Married-spouse-absent               0.959518
## marital Never-married                       5.16e-08 ***
## marital Separated                           0.589277
## marital Widowed                             0.241607
## occupation Armed-Forces                     0.451591
## occupation Craft-repair                     0.430362
## occupation Exec-managerial                   < 2e-16 ***
## occupation Farming-fishing                  3.21e-12 ***
## occupation Handlers-cleaners                1.57e-06 ***
## occupation Machine-op-inspct                0.010360 *
## occupation Other-service                    4.50e-12 ***
## occupation Priv-house-serv                  0.015916 *
## occupation Prof-specialty                   3.87e-10 ***
## occupation Protective-serv                  2.20e-06 ***
## occupation Sales                            0.000403 ***
## occupation Tech-support                     2.66e-09 ***
## occupation Transport-moving                 0.369448
## relationship Not-in-family                  0.095982 .
## relationship Other-relative                 0.109885
## relationship Own-child                      0.006812 **
## relationship Unmarried                      0.242463
## relationship Wife                            < 2e-16 ***
```

```
## race Asian-Pac-Islander                      0.003785 **
## race Black                                   0.070321 .
## race Other                                   0.740237
## race White                                   0.010343 *
## sex Male                                      < 2e-16 ***
## capital.gain                                  < 2e-16 ***
## capital.loss                                  < 2e-16 ***
## hours.per.week                                < 2e-16 ***
## native.country Canada                        0.238944
## native.country China                         0.006439 **
## native.country Columbia                      0.001490 **
## native.country Cuba                          0.270924
## native.country Dominican-Republic            0.016847 *
## native.country Ecuador                       0.144101
## native.country El-Salvador                   0.027612 *
## native.country England                       0.233300
## native.country France                        0.491044
## native.country Germany                       0.311750
## native.country Greece                        0.011087 *
## native.country Guatemala                     0.154334
## native.country Haiti                         0.207295
## native.country Holand-Netherlands            0.989483
## native.country Honduras                      0.376267
## native.country Hong                          0.132285
## native.country Hungary                       0.205684
## native.country India                         0.012746 *
## native.country Iran                          0.138389
## native.country Ireland                       0.488248
## native.country Italy                         0.642116
## native.country Jamaica                       0.144361
## native.country Japan                         0.196881
## native.country Laos                          0.071769 .
## native.country Mexico                        0.013106 *
## native.country Nicaragua                     0.065264 .
## native.country Outlying-US(Guam-USVI-etc) 0.948933
## native.country Peru                          0.059554 .
## native.country Philippines                   0.172770
## native.country Poland                        0.124250
## native.country Portugal                      0.204960
## native.country Puerto-Rico                   0.051129 .
## native.country Scotland                      0.194512
## native.country South                         0.000883 ***
## native.country Taiwan                        0.066463 .
## native.country Thailand                      0.071863 .
## native.country Trinadad&Tobago               0.136166
## native.country United-States                 0.129711
## native.country Vietnam                       0.004601 **
## native.country Yugoslavia                    0.616151
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 33851  on 30161  degrees of freedom
## Residual deviance: 19486  on 30066  degrees of freedom
## AIC: 19678
##
## Number of Fisher Scoring iterations: 13
```

Model 1

We will try dropping the *race* variable as it does not appear to be significant from the p-values (mostly > 0.05).

```
fit_1 = suppressWarnings(glm(formula = class ~ . - race,
          family = binomial,
          data = train))

summary(fit_1)
```

```
##
## Call:
## glm(formula = class ~ . - race, family = binomial, data = train)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -5.1125  -0.5152  -0.1898   0.0000   3.7969
##
## Coefficients:
##                                          Estimate Std. Error z value
## (Intercept)                            -5.615e+00  7.100e-01  -7.907
## age                                     2.567e-02  1.712e-03  14.995
## workclass Local-gov                    -6.884e-01  1.126e-01  -6.114
## workclass Private                      -4.879e-01  9.321e-02  -5.235
## workclass Self-emp-inc                 -3.057e-01  1.234e-01  -2.477
## workclass Self-emp-not-inc             -9.791e-01  1.095e-01  -8.944
## workclass State-gov                    -8.076e-01  1.251e-01  -6.455
## workclass Without-pay                  -1.326e+01  1.973e+02  -0.067
## fnlwgt                                  7.227e-07  1.742e-07   4.149
## education 11th                          9.811e-02  2.139e-01   0.459
## education 12th                          4.474e-01  2.783e-01   1.608
## education 1st-4th                      -4.344e-01  4.956e-01  -0.877
## education 5th-6th                      -3.992e-01  3.590e-01  -1.112
## education 7th-8th                      -5.654e-01  2.434e-01  -2.323
## education 9th                          -2.331e-01  2.699e-01  -0.864
## education Assoc-acdm                    1.283e+00  1.796e-01   7.143
## education Assoc-voc                     1.278e+00  1.728e-01   7.400
## education Bachelors                     1.912e+00  1.606e-01  11.904
## education Doctorate                     2.948e+00  2.228e-01  13.232
## education HS-grad                       7.806e-01  1.562e-01   4.996
```

```
## education Masters                               2.274e+00  1.718e-01  13.239
## education Preschool                            -2.000e+01  1.973e+02  -0.101
## education Prof-school                           2.861e+00  2.070e-01  13.823
## education Some-college                          1.115e+00  1.586e-01   7.030
## marital Married-AF-spouse                       2.782e+00  5.768e-01   4.822
## marital Married-civ-spouse                      2.108e+00  2.746e-01   7.679
## marital Married-spouse-absent                   2.107e-03  2.399e-01   0.009
## marital Never-married                          -4.861e-01  8.915e-02  -5.452
## marital Separated                              -1.045e-01  1.651e-01  -0.633
## marital Widowed                                 1.868e-01  1.581e-01   1.182
## occupation Armed-Forces                        -1.227e+00  1.508e+00  -0.814
## occupation Craft-repair                         6.722e-02  8.071e-02   0.833
## occupation Exec-managerial                      8.083e-01  7.789e-02  10.377
## occupation Farming-fishing                     -9.770e-01  1.406e-01  -6.948
## occupation Handlers-cleaners                   -6.984e-01  1.446e-01  -4.829
## occupation Machine-op-inspct                   -2.704e-01  1.026e-01  -2.635
## occupation Other-service                       -8.330e-01  1.190e-01  -7.002
## occupation Priv-house-serv                     -4.139e+00  1.710e+00  -2.421
## occupation Prof-specialty                       5.166e-01  8.240e-02   6.269
## occupation Protective-serv                      5.935e-01  1.262e-01   4.704
## occupation Sales                                2.975e-01  8.312e-02   3.579
## occupation Tech-support                         6.726e-01  1.116e-01   6.028
## occupation Transport-moving                    -9.750e-02  9.998e-02  -0.975
## relationship Not-in-family                      4.532e-01  2.715e-01   1.669
## relationship Other-relative                    -4.003e-01  2.479e-01  -1.615
## relationship Own-child                         -7.286e-01  2.702e-01  -2.697
## relationship Unmarried                          3.291e-01  2.871e-01   1.146
## relationship Wife                               1.350e+00  1.057e-01  12.773
## sex Male                                        8.702e-01  8.089e-02  10.758
## capital.gain                                    3.218e-04  1.074e-05  29.968
## capital.loss                                    6.429e-04  3.846e-05  16.717
## hours.per.week                                  2.956e-02  1.702e-03  17.365
## native.country Canada                          -1.056e+00  6.668e-01  -1.584
## native.country China                           -1.926e+00  7.038e-01  -2.737
## native.country Columbia                        -3.549e+00  1.013e+00  -3.502
## native.country Cuba                            -1.028e+00  6.813e-01  -1.509
## native.country Dominican-Republic              -3.270e+00  1.206e+00  -2.711
## native.country Ecuador                         -1.771e+00  9.373e-01  -1.889
## native.country El-Salvador                     -1.983e+00  7.731e-01  -2.566
## native.country England                         -1.090e+00  6.789e-01  -1.606
## native.country France                          -8.087e-01  7.945e-01  -1.018
## native.country Germany                         -9.294e-01  6.562e-01  -1.416
## native.country Greece                          -2.372e+00  8.200e-01  -2.893
## native.country Guatemala                       -1.657e+00  9.630e-01  -1.720
## native.country Haiti                           -1.556e+00  9.098e-01  -1.711
## native.country Holand-Netherlands              -1.186e+01  8.827e+02  -0.013
## native.country Honduras                        -2.551e+00  2.611e+00  -0.977
## native.country Hong                            -1.375e+00  8.978e-01  -1.531
## native.country Hungary                         -1.502e+00  9.750e-01  -1.541
## native.country India                           -1.732e+00  6.674e-01  -2.594
```

```
## native.country Iran                       -1.358e+00  7.434e-01  -1.827
## native.country Ireland                    -8.421e-01  8.751e-01  -0.962
## native.country Italy                      -5.712e-01  6.874e-01  -0.831
## native.country Jamaica                    -1.502e+00  7.480e-01  -2.008
## native.country Japan                      -1.041e+00  7.263e-01  -1.433
## native.country Laos                       -1.876e+00  1.046e+00  -1.794
## native.country Mexico                     -1.919e+00  6.419e-01  -2.990
## native.country Nicaragua                  -2.153e+00  1.007e+00  -2.139
## native.country Outlying-US(Guam-USVI-etc) -1.369e+01  2.102e+02  -0.065
## native.country Peru                       -2.225e+00  1.040e+00  -2.140
## native.country Philippines                -9.029e-01  6.442e-01  -1.402
## native.country Poland                     -1.386e+00  7.258e-01  -1.910
## native.country Portugal                   -1.362e+00  8.680e-01  -1.569
## native.country Puerto-Rico                -1.789e+00  7.155e-01  -2.501
## native.country Scotland                   -1.648e+00  1.072e+00  -1.538
## native.country South                      -2.458e+00  7.361e-01  -3.339
## native.country Taiwan                     -1.403e+00  7.539e-01  -1.861
## native.country Thailand                   -1.875e+00  1.019e+00  -1.840
## native.country Trinadad&Tobago            -1.883e+00  1.056e+00  -1.784
## native.country United-States              -1.211e+00  6.062e-01  -1.998
## native.country Vietnam                    -2.399e+00  8.456e-01  -2.837
## native.country Yugoslavia                 -7.046e-01  9.035e-01  -0.780
##                                           Pr(>|z|)
## (Intercept)                               2.63e-15 ***
## age                                        < 2e-16 ***
## workclass Local-gov                       9.72e-10 ***
## workclass Private                         1.65e-07 ***
## workclass Self-emp-inc                    0.013236 *
## workclass Self-emp-not-inc                 < 2e-16 ***
## workclass State-gov                       1.08e-10 ***
## workclass Without-pay                     0.946429
## fnlwgt                                    3.33e-05 ***
## education 11th                            0.646464
## education 12th                            0.107826
## education 1st-4th                         0.380651
## education 5th-6th                         0.266173
## education 7th-8th                         0.020155 *
## education 9th                             0.387810
## education Assoc-acdm                      9.15e-13 ***
## education Assoc-voc                       1.36e-13 ***
## education Bachelors                        < 2e-16 ***
## education Doctorate                        < 2e-16 ***
## education HS-grad                         5.86e-07 ***
## education Masters                          < 2e-16 ***
## education Preschool                       0.919269
## education Prof-school                      < 2e-16 ***
## education Some-college                    2.06e-12 ***
## marital Married-AF-spouse                 1.42e-06 ***
## marital Married-civ-spouse                1.60e-14 ***
## marital Married-spouse-absent             0.992995
```

```
## marital Never-married                          4.97e-08 ***
## marital Separated                              0.526921
## marital Widowed                                0.237308
## occupation Armed-Forces                        0.415756
## occupation Craft-repair                        0.404877
## occupation Exec-managerial                      < 2e-16 ***
## occupation Farming-fishing                     3.71e-12 ***
## occupation Handlers-cleaners                   1.37e-06 ***
## occupation Machine-op-inspct                   0.008409 **
## occupation Other-service                       2.52e-12 ***
## occupation Priv-house-serv                     0.015477 *
## occupation Prof-specialty                      3.62e-10 ***
## occupation Protective-serv                     2.55e-06 ***
## occupation Sales                               0.000345 ***
## occupation Tech-support                        1.67e-09 ***
## occupation Transport-moving                    0.329475
## relationship Not-in-family                     0.095025 .
## relationship Other-relative                    0.106368
## relationship Own-child                         0.007004 **
## relationship Unmarried                         0.251693
## relationship Wife                               < 2e-16 ***
## sex Male                                        < 2e-16 ***
## capital.gain                                    < 2e-16 ***
## capital.loss                                    < 2e-16 ***
## hours.per.week                                  < 2e-16 ***
## native.country Canada                          0.113109
## native.country China                           0.006206 **
## native.country Columbia                        0.000462 ***
## native.country Cuba                            0.131195
## native.country Dominican-Republic              0.006702 **
## native.country Ecuador                         0.058833 .
## native.country El-Salvador                     0.010301 *
## native.country England                         0.108287
## native.country France                          0.308779
## native.country Germany                         0.156655
## native.country Greece                          0.003816 **
## native.country Guatemala                       0.085365 .
## native.country Haiti                           0.087122 .
## native.country Holand-Netherlands              0.989278
## native.country Honduras                        0.328607
## native.country Hong                            0.125672
## native.country Hungary                         0.123393
## native.country India                           0.009475 **
## native.country Iran                            0.067709 .
## native.country Ireland                         0.335890
## native.country Italy                           0.406006
## native.country Jamaica                         0.044620 *
## native.country Japan                           0.151799
## native.country Laos                            0.072802 .
## native.country Mexico                          0.002792 **
```

```
## native.country Nicaragua                   0.032462 *
## native.country Outlying-US(Guam-USVI-etc) 0.948048
## native.country Peru                        0.032333 *
## native.country Philippines                 0.161005
## native.country Poland                      0.056103 .
## native.country Portugal                    0.116613
## native.country Puerto-Rico                 0.012389 *
## native.country Scotland                    0.123997
## native.country South                       0.000841 ***
## native.country Taiwan                      0.062795 .
## native.country Thailand                    0.065710 .
## native.country Trinadad&Tobago             0.074484 .
## native.country United-States               0.045757 *
## native.country Vietnam                     0.004549 **
## native.country Yugoslavia                  0.435500
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 33851  on 30161  degrees of freedom
## Residual deviance: 19501  on 30070  degrees of freedom
## AIC: 19685
##
## Number of Fisher Scoring iterations: 13
```

Prediction the Test Set Results

```
prob_pred_1 = predict(fit_1, type = 'response', newdata = test[-14])
y_pred_1 = ifelse(prob_pred_1 > 0.5, '>50K', '<=50K')

# Confusion Matrix 1
cm_1 = table(test[, 14], y_pred_1)
cm_1

##          y_pred_1
##           <=50K  >50K
##    <=50K. 10537   823
##    >50K.   1470  2230
```

Computing the Accuracy and Error Rates

```
acc_1 = sum(diag(cm_1)) / sum(cm_1)
acc_1

## [1] 0.8477424

err_1 = 1 - acc_1
err_1

## [1] 0.1522576
```

This model has an accuracy rate of **84.77%**, which is only very slightly improved.

Model 1 is our best model so far.

Model 2

We remove the *relationship* variable as well as it appears to be a less significant variable.

```
fit_2 = suppressWarnings(glm(formula = class ~ . - race - relationship,
          family = binomial,
          data = train))

summary(fit_2)

##
## Call:
## glm(formula = class ~ . - race - relationship, family = binomial,
##     data = train)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -5.1465  -0.5077  -0.2119   0.0000   3.7692
##
## Coefficients:
##                                          Estimate Std. Error z value
## (Intercept)                            -4.907e+00  6.515e-01  -7.532
## age                                     2.596e-02  1.685e-03  15.407
## workclass Local-gov                    -6.962e-01  1.117e-01  -6.234
## workclass Private                      -4.847e-01  9.256e-02  -5.237
## workclass Self-emp-inc                 -2.886e-01  1.234e-01  -2.339
## workclass Self-emp-not-inc             -9.597e-01  1.091e-01  -8.793
## workclass State-gov                    -8.097e-01  1.244e-01  -6.510
## workclass Without-pay                  -1.317e+01  1.987e+02  -0.066
## fnlwgt                                  7.475e-07  1.736e-07   4.307
## education 11th                          8.503e-02  2.134e-01   0.398
## education 12th                          4.611e-01  2.778e-01   1.660
## education 1st-4th                      -4.551e-01  4.958e-01  -0.918
## education 5th-6th                      -4.098e-01  3.589e-01  -1.142
## education 7th-8th                      -5.663e-01  2.432e-01  -2.329
## education 9th                          -2.120e-01  2.694e-01  -0.787
## education Assoc-acdm                    1.319e+00  1.792e-01   7.361
## education Assoc-voc                     1.279e+00  1.724e-01   7.418
## education Bachelors                     1.932e+00  1.603e-01  12.051
## education Doctorate                     2.947e+00  2.225e-01  13.245
## education HS-grad                       7.914e-01  1.560e-01   5.073
## education Masters                       2.294e+00  1.713e-01  13.387
## education Preschool                    -2.043e+01  1.890e+02  -0.108
## education Prof-school                   2.877e+00  2.068e-01  13.911
## education Some-college                  1.112e+00  1.583e-01   7.027
## marital Married-AF-spouse               3.065e+00  5.032e-01   6.090
## marital Married-civ-spouse              2.183e+00  6.809e-02  32.066
## marital Married-spouse-absent           4.964e-02  2.360e-01   0.210
```

```
## marital Never-married                        -5.141e-01  8.407e-02  -6.115
## marital Separated                            -1.095e-01  1.616e-01  -0.678
## marital Widowed                               3.762e-02  1.547e-01   0.243
## occupation Armed-Forces                      -1.331e+00  1.525e+00  -0.873
## occupation Craft-repair                       3.651e-03  7.939e-02   0.046
## occupation Exec-managerial                    7.757e-01  7.618e-02  10.183
## occupation Farming-fishing                   -1.057e+00  1.404e-01  -7.531
## occupation Handlers-cleaners                 -7.626e-01  1.441e-01  -5.294
## occupation Machine-op-inspct                 -3.175e-01  1.017e-01  -3.123
## occupation Other-service                     -8.348e-01  1.176e-01  -7.095
## occupation Priv-house-serv                   -4.464e+00  1.726e+00  -2.586
## occupation Prof-specialty                     4.932e-01  8.077e-02   6.106
## occupation Protective-serv                    5.505e-01  1.258e-01   4.377
## occupation Sales                              2.461e-01  8.159e-02   3.016
## occupation Tech-support                       6.340e-01  1.098e-01   5.775
## occupation Transport-moving                  -1.512e-01  9.918e-02  -1.525
## sex Male                                      1.549e-01  5.398e-02   2.869
## capital.gain                                  3.249e-04  1.068e-05  30.406
## capital.loss                                  6.525e-04  3.838e-05  16.999
## hours.per.week                                2.950e-02  1.688e-03  17.473
## native.country Canada                        -1.039e+00  6.706e-01  -1.549
## native.country China                         -1.957e+00  7.083e-01  -2.763
## native.country Columbia                      -3.598e+00  1.017e+00  -3.536
## native.country Cuba                          -1.078e+00  6.821e-01  -1.580
## native.country Dominican-Republic            -3.142e+00  1.211e+00  -2.594
## native.country Ecuador                       -1.836e+00  9.404e-01  -1.952
## native.country El-Salvador                   -1.961e+00  7.769e-01  -2.524
## native.country England                       -1.051e+00  6.824e-01  -1.540
## native.country France                        -7.504e-01  7.999e-01  -0.938
## native.country Germany                       -9.585e-01  6.589e-01  -1.455
## native.country Greece                        -2.376e+00  8.231e-01  -2.886
## native.country Guatemala                     -1.646e+00  9.695e-01  -1.698
## native.country Haiti                         -1.600e+00  8.984e-01  -1.780
## native.country Holand-Netherlands            -1.293e+01  8.827e+02  -0.015
## native.country Honduras                      -2.298e+00  2.325e+00  -0.988
## native.country Hong                          -1.303e+00  9.066e-01  -1.438
## native.country Hungary                       -1.476e+00  9.839e-01  -1.501
## native.country India                         -1.755e+00  6.734e-01  -2.606
## native.country Iran                          -1.373e+00  7.492e-01  -1.832
## native.country Ireland                       -8.464e-01  8.845e-01  -0.957
## native.country Italy                         -5.716e-01  6.902e-01  -0.828
## native.country Jamaica                       -1.491e+00  7.505e-01  -1.986
## native.country Japan                         -1.080e+00  7.309e-01  -1.478
## native.country Laos                          -1.842e+00  1.058e+00  -1.741
## native.country Mexico                        -1.932e+00  6.463e-01  -2.989
## native.country Nicaragua                     -2.099e+00  1.009e+00  -2.081
## native.country Outlying-US(Guam-USVI-etc)    -1.354e+01  2.136e+02  -0.063
## native.country Peru                          -2.231e+00  1.045e+00  -2.135
## native.country Philippines                   -1.000e+00  6.472e-01  -1.545
## native.country Poland                        -1.418e+00  7.297e-01  -1.943
```

```
## native.country Portugal                    -1.238e+00  8.705e-01  -1.423
## native.country Puerto-Rico                 -1.708e+00  7.186e-01  -2.377
## native.country Scotland                    -1.478e+00  1.105e+00  -1.337
## native.country South                       -2.401e+00  7.383e-01  -3.252
## native.country Taiwan                      -1.410e+00  7.520e-01  -1.875
## native.country Thailand                    -1.823e+00  9.969e-01  -1.828
## native.country Trinadad&Tobago             -1.776e+00  1.054e+00  -1.685
## native.country United-States               -1.211e+00  6.107e-01  -1.983
## native.country Vietnam                     -2.459e+00  8.495e-01  -2.894
## native.country Yugoslavia                  -7.617e-01  9.076e-01  -0.839
##                                            Pr(>|z|)
## (Intercept)                                5.00e-14 ***
## age                                         < 2e-16 ***
## workclass Local-gov                        4.55e-10 ***
## workclass Private                          1.63e-07 ***
## workclass Self-emp-inc                     0.019331 *
## workclass Self-emp-not-inc                  < 2e-16 ***
## workclass State-gov                        7.52e-11 ***
## workclass Without-pay                      0.947131
## fnlwgt                                     1.66e-05 ***
## education 11th                             0.690349
## education 12th                             0.096984 .
## education 1st-4th                          0.358698
## education 5th-6th                          0.253590
## education 7th-8th                          0.019856 *
## education 9th                              0.431193
## education Assoc-acdm                       1.82e-13 ***
## education Assoc-voc                        1.19e-13 ***
## education Bachelors                         < 2e-16 ***
## education Doctorate                         < 2e-16 ***
## education HS-grad                          3.92e-07 ***
## education Masters                           < 2e-16 ***
## education Preschool                        0.913927
## education Prof-school                       < 2e-16 ***
## education Some-college                     2.10e-12 ***
## marital Married-AF-spouse                  1.13e-09 ***
## marital Married-civ-spouse                  < 2e-16 ***
## marital Married-spouse-absent              0.833402
## marital Never-married                      9.63e-10 ***
## marital Separated                          0.497894
## marital Widowed                            0.807930
## occupation Armed-Forces                    0.382836
## occupation Craft-repair                    0.963320
## occupation Exec-managerial                  < 2e-16 ***
## occupation Farming-fishing                 5.03e-14 ***
## occupation Handlers-cleaners               1.20e-07 ***
## occupation Machine-op-inspct               0.001790 **
## occupation Other-service                   1.29e-12 ***
## occupation Priv-house-serv                 0.009697 **
## occupation Prof-specialty                  1.02e-09 ***
```

```
## occupation Protective-serv                1.20e-05 ***
## occupation Sales                          0.002558 **
## occupation Tech-support                   7.71e-09 ***
## occupation Transport-moving               0.127245
## sex Male                                  0.004117 **
## capital.gain                               < 2e-16 ***
## capital.loss                               < 2e-16 ***
## hours.per.week                             < 2e-16 ***
## native.country Canada                     0.121407
## native.country China                      0.005732 **
## native.country Columbia                   0.000406 ***
## native.country Cuba                       0.114067
## native.country Dominican-Republic         0.009484 **
## native.country Ecuador                    0.050954 .
## native.country El-Salvador                0.011614 *
## native.country England                    0.123658
## native.country France                     0.348227
## native.country Germany                    0.145750
## native.country Greece                     0.003897 **
## native.country Guatemala                  0.089549 .
## native.country Haiti                      0.075013 .
## native.country Holand-Netherlands         0.988318
## native.country Honduras                   0.323019
## native.country Hong                       0.150499
## native.country Hungary                    0.133444
## native.country India                      0.009156 **
## native.country Iran                       0.066910 .
## native.country Ireland                    0.338616
## native.country Italy                      0.407571
## native.country Jamaica                    0.047015 *
## native.country Japan                      0.139346
## native.country Laos                       0.081625 .
## native.country Mexico                     0.002799 **
## native.country Nicaragua                  0.037463 *
## native.country Outlying-US(Guam-USVI-etc) 0.949445
## native.country Peru                       0.032747 *
## native.country Philippines                0.122232
## native.country Poland                     0.051960 .
## native.country Portugal                   0.154880
## native.country Puerto-Rico                0.017455 *
## native.country Scotland                   0.181291
## native.country South                      0.001147 **
## native.country Taiwan                     0.060777 .
## native.country Thailand                   0.067504 .
## native.country Trinadad&Tobago            0.091952 .
## native.country United-States              0.047365 *
## native.country Vietnam                    0.003803 **
## native.country Yugoslavia                 0.401278
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 33851  on 30161  degrees of freedom
## Residual deviance: 19767  on 30075  degrees of freedom
## AIC: 19941
##
## Number of Fisher Scoring iterations: 13
```

Prediction the Test Set Results

```
prob_pred_2 = predict(fit_2, type = 'response', newdata = test[-14])
y_pred_2 = ifelse(prob_pred_2 > 0.5, '>50K', '<=50K')

cm_2 = table(test[, 14], y_pred_2)
cm_2
```

```
##          y_pred_2
##           <=50K  >50K
##   <=50K. 10554   806
##   >50K.   1504  2196
```

Computing the Accuracy and Error Rates

```
acc_2 = sum(diag(cm_2)) / sum(cm_2)
acc_2
```

```
## [1] 0.8466135
```

```
err_2 = 1 - acc_2
err_2
```

```
## [1] 0.1533865
```

However, accuracy rate has decreased to **84.66**.

Model 3

We will do more data cleaning, for it appears that there are many zero values present in the *capital.loss* and *capital.gain* columns. Let's remove these from our best model so far (Model 1) and see if the result improves.

```
fit_3 = suppressWarnings(glm(formula = class ~ . - race - capital.gain - capi
tal.loss,
          family = binomial,
          data = train))

summary(fit_3)
```

```
##
## Call:
## glm(formula = class ~ . - race - capital.gain - capital.loss,
##     family = binomial, data = train)
```

```
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.6754  -0.5672  -0.2165  -0.0005   3.7071
##
## Coefficients:
##                                        Estimate Std. Error z value
## (Intercept)                          -5.511e+00  6.843e-01  -8.053
## age                                   2.901e-02  1.627e-03  17.834
## workclass Local-gov                  -6.543e-01  1.078e-01  -6.071
## workclass Private                    -4.388e-01  8.910e-02  -4.925
## workclass Self-emp-inc               -1.950e-01  1.171e-01  -1.665
## workclass Self-emp-not-inc           -8.986e-01  1.043e-01  -8.616
## workclass State-gov                  -8.377e-01  1.201e-01  -6.977
## workclass Without-pay                -1.337e+01  1.953e+02  -0.068
## fnlwgt                                7.609e-07  1.658e-07   4.590
## education 11th                        1.601e-01  2.058e-01   0.778
## education 12th                        5.000e-01  2.615e-01   1.912
## education 1st-4th                    -4.230e-01  4.704e-01  -0.899
## education 5th-6th                    -3.329e-01  3.502e-01  -0.951
## education 7th-8th                    -5.529e-01  2.352e-01  -2.351
## education 9th                        -2.938e-01  2.623e-01  -1.120
## education Assoc-acdm                  1.338e+00  1.715e-01   7.799
## education Assoc-voc                   1.362e+00  1.647e-01   8.272
## education Bachelors                   2.005e+00  1.535e-01  13.064
## education Doctorate                   3.105e+00  2.112e-01  14.701
## education HS-grad                     8.293e-01  1.493e-01   5.554
## education Masters                     2.426e+00  1.638e-01  14.814
## education Preschool                  -1.112e+01  1.085e+02  -0.103
## education Prof-school                 3.107e+00  1.954e-01  15.901
## education Some-college                1.162e+00  1.515e-01   7.669
## marital Married-AF-spouse             2.517e+00  5.661e-01   4.446
## marital Married-civ-spouse            1.995e+00  2.662e-01   7.492
## marital Married-spouse-absent        -3.755e-02  2.212e-01  -0.170
## marital Never-married                -4.553e-01  8.161e-02  -5.579
## marital Separated                    -8.774e-02  1.511e-01  -0.581
## marital Widowed                       1.759e-01  1.439e-01   1.222
## occupation Armed-Forces              -9.862e-01  1.282e+00  -0.769
## occupation Craft-repair               6.640e-02  7.668e-02   0.866
## occupation Exec-managerial            8.242e-01  7.359e-02  11.200
## occupation Farming-fishing           -9.415e-01  1.319e-01  -7.138
## occupation Handlers-cleaners         -7.195e-01  1.384e-01  -5.200
## occupation Machine-op-inspct         -3.031e-01  9.832e-02  -3.083
## occupation Other-service             -9.176e-01  1.139e-01  -8.058
## occupation Priv-house-serv           -2.541e+00  1.113e+00  -2.282
## occupation Prof-specialty             5.255e-01  7.798e-02   6.739
## occupation Protective-serv            5.474e-01  1.210e-01   4.523
## occupation Sales                      3.105e-01  7.850e-02   3.955
## occupation Tech-support               6.265e-01  1.071e-01   5.852
## occupation Transport-moving          -1.221e-01  9.513e-02  -1.284
```

```
## relationship Not-in-family                    4.550e-01  2.636e-01   1.726
## relationship Other-relative                  -4.417e-01  2.392e-01  -1.846
## relationship Own-child                       -7.567e-01  2.643e-01  -2.863
## relationship Unmarried                        2.608e-01  2.771e-01   0.941
## relationship Wife                             1.366e+00  9.874e-02  13.836
## sex Male                                      8.678e-01  7.387e-02  11.747
## hours.per.week                                3.013e-02  1.622e-03  18.572
## native.country Canada                        -1.095e+00  6.434e-01  -1.702
## native.country China                         -1.926e+00  6.824e-01  -2.823
## native.country Columbia                      -3.778e+00  1.016e+00  -3.718
## native.country Cuba                          -1.126e+00  6.584e-01  -1.710
## native.country Dominican-Republic            -2.779e+00  9.639e-01  -2.883
## native.country Ecuador                       -1.828e+00  8.875e-01  -2.060
## native.country El-Salvador                   -1.740e+00  7.417e-01  -2.346
## native.country England                       -1.076e+00  6.579e-01  -1.636
## native.country France                        -8.657e-01  7.876e-01  -1.099
## native.country Germany                       -9.555e-01  6.322e-01  -1.511
## native.country Greece                        -2.058e+00  7.774e-01  -2.647
## native.country Guatemala                     -1.592e+00  8.907e-01  -1.788
## native.country Haiti                         -1.669e+00  8.821e-01  -1.893
## native.country Holand-Netherlands            -1.073e+01  8.827e+02  -0.012
## native.country Honduras                      -2.386e+00  2.100e+00  -1.136
## native.country Hong                          -1.603e+00  8.770e-01  -1.827
## native.country Hungary                       -1.481e+00  9.316e-01  -1.590
## native.country India                         -1.776e+00  6.423e-01  -2.766
## native.country Iran                          -1.322e+00  7.065e-01  -1.871
## native.country Ireland                       -8.642e-01  8.525e-01  -1.014
## native.country Italy                         -6.506e-01  6.646e-01  -0.979
## native.country Jamaica                       -1.628e+00  7.172e-01  -2.270
## native.country Japan                         -1.067e+00  6.967e-01  -1.531
## native.country Laos                          -2.080e+00  1.052e+00  -1.978
## native.country Mexico                        -1.987e+00  6.198e-01  -3.206
## native.country Nicaragua                     -2.281e+00  1.001e+00  -2.278
## native.country Outlying-US(Guam-USVI-etc) -1.400e+01  2.084e+02  -0.067
## native.country Peru                          -2.286e+00  9.909e-01  -2.308
## native.country Philippines                   -9.729e-01  6.218e-01  -1.565
## native.country Poland                        -1.470e+00  7.090e-01  -2.074
## native.country Portugal                      -1.480e+00  8.596e-01  -1.722
## native.country Puerto-Rico                   -1.800e+00  6.904e-01  -2.607
## native.country Scotland                      -1.957e+00  1.063e+00  -1.840
## native.country South                         -2.417e+00  6.967e-01  -3.469
## native.country Taiwan                        -1.590e+00  7.272e-01  -2.186
## native.country Thailand                      -2.194e+00  1.006e+00  -2.181
## native.country Trinadad&Tobago               -1.953e+00  1.013e+00  -1.928
## native.country United-States                 -1.216e+00  5.858e-01  -2.076
## native.country Vietnam                       -2.235e+00  8.033e-01  -2.782
## native.country Yugoslavia                    -8.269e-01  8.774e-01  -0.942
##                                              Pr(>|z|)
## (Intercept)                                  8.08e-16 ***
## age                                           < 2e-16 ***
```

```
## workclass Local-gov                             1.27e-09 ***
## workclass Private                               8.42e-07 ***
## workclass Self-emp-inc                          0.095955 .
## workclass Self-emp-not-inc                       < 2e-16 ***
## workclass State-gov                             3.01e-12 ***
## workclass Without-pay                           0.945409
## fnlwgt                                          4.43e-06 ***
## education 11th                                  0.436659
## education 12th                                  0.055908 .
## education 1st-4th                               0.368534
## education 5th-6th                               0.341741
## education 7th-8th                               0.018728 *
## education 9th                                   0.262668
## education Assoc-acdm                            6.23e-15 ***
## education Assoc-voc                              < 2e-16 ***
## education Bachelors                              < 2e-16 ***
## education Doctorate                              < 2e-16 ***
## education HS-grad                               2.79e-08 ***
## education Masters                                < 2e-16 ***
## education Preschool                             0.918345
## education Prof-school                            < 2e-16 ***
## education Some-college                          1.73e-14 ***
## marital Married-AF-spouse                       8.77e-06 ***
## marital Married-civ-spouse                      6.79e-14 ***
## marital Married-spouse-absent                   0.865167
## marital Never-married                           2.42e-08 ***
## marital Separated                               0.561557
## marital Widowed                                 0.221520
## occupation Armed-Forces                         0.441618
## occupation Craft-repair                         0.386556
## occupation Exec-managerial                       < 2e-16 ***
## occupation Farming-fishing                      9.44e-13 ***
## occupation Handlers-cleaners                    1.99e-07 ***
## occupation Machine-op-inspct                    0.002052 **
## occupation Other-service                        7.78e-16 ***
## occupation Priv-house-serv                      0.022478 *
## occupation Prof-specialty                       1.59e-11 ***
## occupation Protective-serv                      6.10e-06 ***
## occupation Sales                                7.66e-05 ***
## occupation Tech-support                         4.86e-09 ***
## occupation Transport-moving                     0.199116
## relationship Not-in-family                      0.084413 .
## relationship Other-relative                     0.064860 .
## relationship Own-child                          0.004195 **
## relationship Unmarried                          0.346482
## relationship Wife                                < 2e-16 ***
## sex Male                                         < 2e-16 ***
## hours.per.week                                   < 2e-16 ***
## native.country Canada                           0.088800 .
## native.country China                            0.004765 **
```

```
## native.country Columbia                   0.000200 ***
## native.country Cuba                       0.087222 .
## native.country Dominican-Republic         0.003940 **
## native.country Ecuador                    0.039383 *
## native.country El-Salvador                0.018952 *
## native.country England                    0.101862
## native.country France                     0.271686
## native.country Germany                    0.130686
## native.country Greece                     0.008129 **
## native.country Guatemala                  0.073806 .
## native.country Haiti                      0.058415 .
## native.country Holand-Netherlands         0.990299
## native.country Honduras                   0.255750
## native.country Hong                       0.067648 .
## native.country Hungary                    0.111904
## native.country India                      0.005681 **
## native.country Iran                       0.061347 .
## native.country Ireland                    0.310691
## native.country Italy                      0.327626
## native.country Jamaica                    0.023180 *
## native.country Japan                      0.125673
## native.country Laos                       0.047900 *
## native.country Mexico                     0.001347 **
## native.country Nicaragua                  0.022754 *
## native.country Outlying-US(Guam-USVI-etc) 0.946461
## native.country Peru                       0.021024 *
## native.country Philippines                0.117635
## native.country Poland                     0.038103 *
## native.country Portugal                   0.085115 .
## native.country Puerto-Rico                0.009128 **
## native.country Scotland                   0.065725 .
## native.country South                      0.000522 ***
## native.country Taiwan                     0.028807 *
## native.country Thailand                   0.029210 *
## native.country Trinadad&Tobago            0.053803 .
## native.country United-States              0.037914 *
## native.country Vietnam                    0.005397 **
## native.country Yugoslavia                 0.345966
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 33851  on 30161  degrees of freedom
## Residual deviance: 21424  on 30072  degrees of freedom
## AIC: 21604
##
## Number of Fisher Scoring iterations: 13
```

AIC appears to have risen, which is a sign of a worse fit.

Prediction the Test Set Results

```
prob_pred_3 = predict(fit_3, type = 'response', newdata = test[-14])
y_pred_3 = ifelse(prob_pred_3 > 0.5, '>50K', '<=50K')

cm_3 = table(test[, 14], y_pred_3)
cm_3

##          y_pred_3
##           <=50K  >50K
##    <=50K. 10415   945
##    >50K.   1616  2084
```

Computing the Accuracy and Error Rates

```
acc_3 = sum(diag(cm_3)) / sum(cm_3)
acc_3

## [1] 0.8299469

err_3 = 1 - acc_3
err_3

## [1] 0.1700531
```

Accuracy rate has decreased to **82.99%** in this case.

Model 4

We will try feature transformation in this last model, by means of Principal Component Analysis (PCA). To prepare our datasets for this, we will need to create dummy variables.

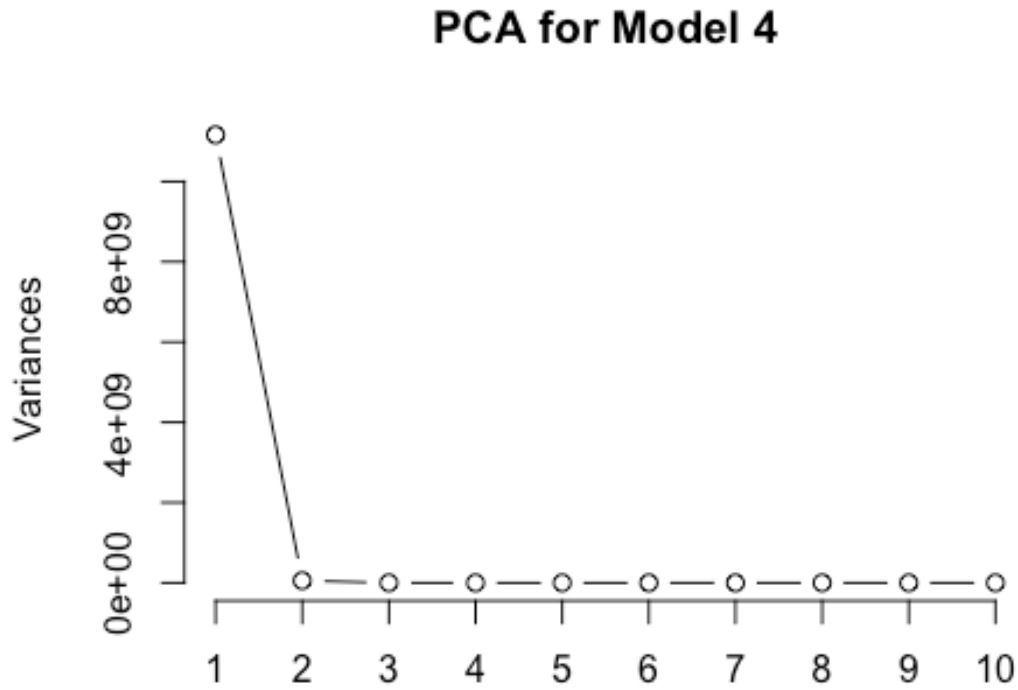
```
# install.packages('dummies')
library(dummies)

## dummies-1.5.6 provided by Decision Patterns

train_4 = dummy.data.frame(train, names = c('workclass','education', 'marital
','occupation',
                                            'relationship','race','sex','nati
ve.country'))
test_4 = dummy.data.frame(test, names = c('workclass','education', 'marital',
'occupation',
                                            'relationship','race','sex','nati
ve.country'))

train_4_pca = prcomp(train_4[-104])
test_4_pca = prcomp(test_4[-103])

screeplot(train_4_pca, type = 'l', main = 'PCA for Model 4')
```




```
summary(train_4_pca)

## Importance of components:
##                              PC1       PC2       PC3   PC4   PC5    PC6
## Standard deviation     1.057e+05 7.406e+03 404.06991 13.26 11.67 0.8597
## Proportion of Variance 9.951e-01 4.890e-03   0.00001  0.00  0.00 0.0000
## Cumulative Proportion  9.951e-01 1.000e+00   1.00000  1.00  1.00 1.0000
##                           PC7    PC8    PC9   PC10  PC11   PC12   PC13
## Standard deviation     0.5582 0.5482 0.4821 0.4571 0.439 0.4211 0.3845
## Proportion of Variance 0.0000 0.0000 0.0000 0.0000 0.000 0.0000 0.0000
## Cumulative Proportion  1.0000 1.0000 1.0000 1.0000 1.000 1.0000 1.0000
##                         PC14   PC15   PC16   PC17   PC18  PC19   PC20
## Standard deviation     0.369 0.3481 0.3437 0.3354 0.3145 0.303 0.2918
## Proportion of Variance 0.000 0.0000 0.0000 0.0000 0.0000 0.000 0.0000
## Cumulative Proportion  1.000 1.0000 1.0000 1.0000 1.0000 1.000 1.0000
##                          PC21   PC22   PC23   PC24   PC25   PC26   PC27
## Standard deviation     0.2841 0.2703 0.2598 0.2397 0.2318 0.2254 0.2149
## Proportion of Variance 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
## Cumulative Proportion  1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000
##                          PC28   PC29   PC30   PC31   PC32   PC33   PC34
## Standard deviation     0.2107 0.2083 0.1985 0.1899 0.1886 0.1854 0.1814
## Proportion of Variance 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
## Cumulative Proportion  1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000
```

```
##                           PC35   PC36   PC37   PC38   PC39  PC40   PC41
## Standard deviation     0.1797 0.1776 0.1698 0.1642 0.1619 0.142 0.1404
## Proportion of Variance 0.0000 0.0000 0.0000 0.0000 0.0000 0.000 0.0000
## Cumulative Proportion  1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.0000
##                           PC42   PC43   PC44   PC45  PC46   PC47   PC48
## Standard deviation     0.1293 0.1237 0.1221 0.1178 0.115 0.1116 0.1041
## Proportion of Variance 0.0000 0.0000 0.0000 0.0000 0.000 0.0000 0.0000
## Cumulative Proportion  1.0000 1.0000 1.0000 1.0000 1.000 1.0000 1.0000
##                            PC49    PC50    PC51    PC52    PC53    PC54
## Standard deviation     0.09095 0.09028 0.07307 0.07207 0.06837 0.06381
## Proportion of Variance 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
## Cumulative Proportion  1.00000 1.00000 1.00000 1.00000 1.00000 1.00000
##                            PC55    PC56    PC57    PC58    PC59   PC60
## Standard deviation     0.05941 0.05804 0.05754 0.05604 0.05528 0.0541
## Proportion of Variance 0.00000 0.00000 0.00000 0.00000 0.00000 0.0000
## Cumulative Proportion  1.00000 1.00000 1.00000 1.00000 1.00000 1.0000
##                            PC61    PC62    PC63    PC64    PC65    PC66
## Standard deviation     0.05193 0.04921 0.04794 0.04681 0.04656 0.04582
## Proportion of Variance 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
## Cumulative Proportion  1.00000 1.00000 1.00000 1.00000 1.00000 1.00000
##                            PC67    PC68    PC69   PC70    PC71    PC72
## Standard deviation     0.04451 0.04386 0.04301 0.0404 0.03941 0.03868
## Proportion of Variance 0.00000 0.00000 0.00000 0.0000 0.00000 0.00000
## Cumulative Proportion  1.00000 1.00000 1.00000 1.0000 1.00000 1.00000
##                            PC73    PC74    PC75    PC76    PC77    PC78
## Standard deviation     0.03712 0.03559 0.03334 0.03298 0.03187 0.03117
## Proportion of Variance 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
## Cumulative Proportion  1.00000 1.00000 1.00000 1.00000 1.00000 1.00000
##                            PC79    PC80    PC81   PC82    PC83    PC84
## Standard deviation     0.03024 0.02974 0.02841 0.0273 0.02519 0.02477
## Proportion of Variance 0.00000 0.00000 0.00000 0.0000 0.00000 0.00000
## Cumulative Proportion  1.00000 1.00000 1.00000 1.0000 1.00000 1.00000
##                            PC85    PC86    PC87    PC88    PC89    PC90
## Standard deviation     0.02417 0.02372 0.02364 0.02319 0.02266 0.02149
## Proportion of Variance 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
## Cumulative Proportion  1.00000 1.00000 1.00000 1.00000 1.00000 1.00000
##                            PC91 PC92    PC93    PC94     PC95     PC96
## Standard deviation     0.02079 0.02 0.01917 0.01781 0.005818 1.05e-11
## Proportion of Variance 0.00000 0.00 0.00000 0.00000 0.000000 0.00e+00
## Cumulative Proportion  1.00000 1.00 1.00000 1.00000 1.000000 1.00e+00
##                            PC97     PC98     PC99    PC100    PC101
## Standard deviation     1.05e-11 1.05e-11 1.05e-11 1.05e-11 1.05e-11
## Proportion of Variance 0.00e+00 0.00e+00 0.00e+00 0.00e+00 0.00e+00
## Cumulative Proportion  1.00e+00 1.00e+00 1.00e+00 1.00e+00 1.00e+00
##                           PC102     PC103
## Standard deviation     1.05e-11 7.278e-14
## Proportion of Variance 0.00e+00 0.000e+00
## Cumulative Proportion  1.00e+00 1.000e+00
```

The first 2 principal components are sufficient to explain most, if not all of the variation in the variables. So we will use them for the fit.

```
# Joining PC1 and PC2 columns to the train_4 dataset
train_4_pca_df = as.data.frame(train_4_pca$x)
train_4$PC1 = train_4_pca_df$PC1
train_4$PC2 = train_4_pca_df$PC2

# Joining PC1 and PC2 columns to the test_4 dataset
test_4_pca_df = as.data.frame(test_4_pca$x)
test_4$PC1 = test_4_pca_df$PC1
test_4$PC2 = test_4_pca_df$PC2

fit_4 = suppressWarnings(glm(class ~ PC1 + PC2,
                             family = 'binomial',
                             data = train_4))

summary(fit_4)

##
## Call:
## glm(formula = class ~ PC1 + PC2, family = "binomial", data = train_4)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -4.9964  -0.6879  -0.6832  -0.6521   1.8616
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -9.670e-01  1.543e-02 -62.689   <2e-16 ***
## PC1         -1.888e-07  1.353e-07  -1.395    0.163
## PC2          3.345e-04  8.916e-06  37.519   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 33851  on 30161  degrees of freedom
## Residual deviance: 30698  on 30159  degrees of freedom
## AIC: 30704
##
## Number of Fisher Scoring iterations: 6
```

Prediction the Test Set Results

```
prob_pred_4 = predict(fit_4, type = 'response', newdata = test_4[c(104, 105)]
)
y_pred_4 = ifelse(prob_pred_4 > 0.5, '>50K', '<=50K')

cm_4 = table(test_4[, 103], y_pred_4)
cm_4
```

```
##          y_pred_4
##           <=50K  >50K
##    <=50K. 11200   160
##    >50K.   2970   730
```

Computing the Accuracy and Error Rates

```
acc_4 = sum(diag(cm_4)) / sum(cm_4)
acc_4

## [1] 0.7921647

err_4 = 1 - acc_4
err_4

## [1] 0.2078353
```

Accuracy rate has decreased to **79.22%** for this model, which shows that feature transformation does not improve our results.

Summary & Conclusion

We have used the following models in our analysis to predict the *class* variable:

- Full Model (fit) - using **all** variables
- Model 1 (fit_1) - using all **except** *race*
- Model 2 (fit_2) - using all **except** *race* and *relationship*
- Model 3 (fit_3) - using all **except** *race*, *capital.gain* and *capital.loss*
- Model 4 (fit_4) - using 1st 2 components of PCA

We can conclude that **Model 1** produces the best result, with the *race* variable excluded. This model has the highest accuracy rate of **84.77%**.