Logistic Regression & Elastic Net Regression

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text feature engineering:

```
wine_words <- function(df, j = 1000, stem=F){
  library(tidytext)
  library(SnowballC)
  data(stop_words)
  words <- df %>%
    unnest_tokens(word, description) %>%
    anti_join(stop_words) %>% # get rid of stop words
    filter(!(word %in% c("wine","pinot","vineyard", "price", "points")))

  if(stem){
    words <- words %>%
      mutate(word = wordStem(word))
  }

  words <- words %>%
    count(id, word) %>%
    group_by(id) %>%
    mutate(exists = (n>0)) %>%
    ungroup %>%
    group_by(word) %>%
    mutate(total = sum(n)) %>%
    filter(total > j) %>%
    pivot_wider(id_cols = id, names_from = word, values_from = exists, values_fill = list(
    right_join(select(df,id,province)) %>%
    mutate(across(-province, ~replace_na(.x, F)))
}
wino <- wine_words(wine, j=400, stem=F)
```

```
Joining with `by = join_by(word)`
```

```
Joining with `by = join_by(id)`
```

bringing back numerical features from original dataset to wino:

```
wino = wino %>% left_join(select(wine, id, price, points, year), by = "id")
```

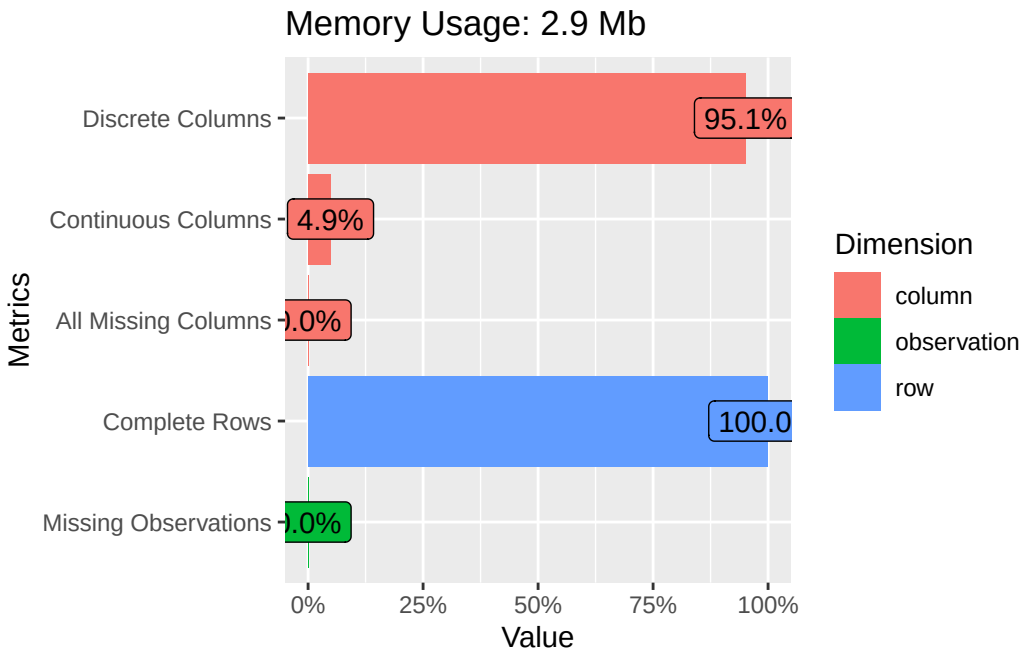
Numerical feature engineering:

```
#center and scale points:
wino = wino %>% select(points) %>% preProcess(method = c("center", "scale")) %>% predict(w


#year as factor, logprice:
wino = wino %>% mutate(year_f = as.factor(year),
                       lprice = log(price))
#binning year and and price:
wino = wino %>%
  mutate(price_f = case_when(
    price < 16 ~ "low",
    price >= 16 & price < 41 ~ "med",
    price >= 41 ~ "high"
  ),
   year_f = case_when(
    year < 2005 ~ "old",
    year >= 2005 & year < 2011 ~ "recent",
    year >= 2011 ~ "current"
  ))
wino = wino %>% dplyr::select(-price)
#difference of wine's lprice from total average lprice
wino = wino %>% mutate(diff_from_avg_lprice = mean(lprice) - lprice)
wino = wino %>% mutate(cost_per_point = lprice/points)
wino = wino %>% select(-id)
wino = wino %>% select(-diff_from_avg_lprice)

head(wino)
```

```
# A tibble: 6 x 82
  bottling earthy herbal berry chocolate drink herb  oak   tart  aromas bodied
  <lgl>    <lgl>  <lgl>  <lgl> <lgl>     <lgl> <lgl> <lgl> <lgl> <lgl>  <lgl>
1 TRUE     TRUE   TRUE   FALSE FALSE     FALSE FALSE FALSE FALSE FALSE  FALSE
2 FALSE    FALSE  FALSE  TRUE  TRUE      TRUE  TRUE  TRUE  TRUE  FALSE  FALSE
3 FALSE    FALSE  FALSE  FALSE FALSE     FALSE FALSE TRUE  FALSE TRUE   TRUE
```

```
4 FALSE    FALSE  TRUE   FALSE FALSE     FALSE TRUE  FALSE FALSE FALSE  FALSE
5 FALSE    TRUE   FALSE  TRUE  FALSE     FALSE FALSE FALSE FALSE FALSE  FALSE
6 FALSE    FALSE  FALSE  FALSE FALSE     TRUE  FALSE FALSE FALSE FALSE  FALSE
# ... with 71 more variables: earth <lgl>, forest <lgl>, offers <lgl>,
#   raspberry <lgl>, smooth <lgl>, spice <lgl>, texture <lgl>, finish <lgl>,
#   flavor <lgl>, fruit <lgl>, notes <lgl>, sweet <lgl>, touch <lgl>,
#   flavors <lgl>, tannins <lgl>, fruity <lgl>, strawberry <lgl>,
#   cranberry <lgl>, dark <lgl>, palate <lgl>, acidity <lgl>, black <lgl>,
#   cherry <lgl>, cola <lgl>, dried <lgl>, nose <lgl>, soft <lgl>, juicy <lgl>,
#   ripe <lgl>, light <lgl>, spicy <lgl>, red <lgl>, age <lgl>, bit <lgl>, ...
```

```r
library("DataExplorer")

plot_intro(wino)
```



Split data

```r
set.seed(100)
wine_index <- createDataPartition(wino$province, p = 0.80, list = FALSE)

train <- wino[ wine_index, ]
```

```r
test <- wino[-wine_index, ]

table(train$province)
```

```
       Burgundy        California Casablanca_Valley       Marlborough
            955              3168               105               184
       New_York            Oregon
            105              2190
```

```r
nrow(train)
```

```
[1] 6707
```

```r
nrow(test)
```

```
[1] 1673
```

Fit Model

```r
# Fit the mode

control <- trainControl(method="cv",
                        number=10,
                        savePredictions="all",
                        classProbs=TRUE)

model <- nnet::multinom(province ~.,
                        data = train,
                        trControl=control)
```

```
# weights:  510 (420 variable)
initial  value 12017.330760
iter  10 value 8583.350102
iter  20 value 3447.156328
iter  30 value 2928.883427
iter  40 value 2399.319643
iter  50 value 2184.899194
```

```
iter  60 value 2062.258244
iter  70 value 1942.942586
iter  80 value 1897.121134
iter  90 value 1846.706928
iter 100 value 1823.360759
final  value 1823.360759
stopped after 100 iterations
```

```
print(model)
```

```
Call:
nnet::multinom(formula = province ~ ., data = train, trControl = control)

Coefficients:
                  (Intercept) bottlingTRUE  earthyTRUE herbalTRUE   berryTRUE
California        -2.04158110    2.3326692  2.33442850  2.6184997 -1.48538107
Casablanca_Valley -0.06739038    0.4766752  1.61014621  4.4720869  1.16357544
Marlborough        0.27853449    2.1998386 -0.05894852  2.8450814 -2.26217716
New_York          -0.05014946   -2.1480213  1.15189817  0.2317209  0.02374801
Oregon             1.42782315    1.3700733  0.98981926  2.6651440 -0.54422312
                  chocolateTRUE  drinkTRUE herbTRUE  oakTRUE tartTRUE
California         -0.166739656 -3.7928243 3.533443 3.913317 3.450648
Casablanca_Valley   3.226693701 -1.0833661 1.330802 4.491435 1.671139
Marlborough        -0.004645711  0.9308882 3.272825 3.564568 4.096477
New_York            0.782712010 -2.9616338 3.815811 2.849237 4.919106
Oregon              2.744276860 -2.2503736 3.724253 2.957143 4.056568
                  aromasTRUE bodiedTRUE earthTRUE forestTRUE offersTRUE
California         3.6439574  3.1391903  3.634394   4.343958  1.3704178
Casablanca_Valley  5.7297169  2.4463713  3.705557   1.514228  0.1120805
Marlborough        2.7851630  3.7523902  4.307556   4.403705  1.3266324
New_York           2.8690169  3.7222451  4.335826   2.696723 -0.8010808
Oregon             0.9459013  0.8677576  3.575171   2.224639  1.0973870
                  raspberryTRUE smoothTRUE  spiceTRUE textureTRUE finishTRUE
California            0.8460102  0.5293772 -0.1996805   0.8533104   1.414024
Casablanca_Valley     2.7819477  1.4035946  1.3082230  -2.8019570   3.185967
Marlborough          -0.7162472  1.2767656 -1.5948409   0.2435642   2.686562
New_York              1.3646539 -1.9712688  0.1666820  -1.7221301   2.646113
Oregon                0.6423684  0.7358623 -1.5175011  -1.7813671   1.682287
                  flavorTRUE   fruitTRUE notesTRUE  sweetTRUE touchTRUE
California         1.0873866 -1.26884697  2.294055  0.5982191 -1.853642
Casablanca_Valley  3.3747378 -1.22965762  3.837704  1.7436841 -2.219160
```

```
Marlborough       -0.4006780  0.02324362  4.152935 -1.0059028 -1.012609
New_York           0.9511496 -1.81661253  4.251899  1.2714178 -3.005321
Oregon             1.0969265  0.69160971  2.319266  0.9579421 -1.396591
                  flavorsTRUE tanninsTRUE fruityTRUE strawberryTRUE
California         -0.3409887  -1.6776045  -2.521548     -0.1487858
Casablanca_Valley   2.3344046  -2.8408571  -1.884170     -2.6385206
Marlborough        -0.4535177  -0.8731573  -6.202920     -3.3645528
New_York            0.4065842   1.4762037  -3.643402     -0.1588614
Oregon              0.8668873  -1.5327612  -1.850547     -0.5642598
                  cranberryTRUE    darkTRUE palateTRUE acidityTRUE  blackTRUE
California            2.2420927 -0.03308997   2.611196  -1.5886729  0.1379426
Casablanca_Valley     0.1972379 -1.19743158   3.870187  -0.6427209 -0.2267637
Marlborough           1.2378438 -0.77904225   2.386708  -5.0288805  0.1630800
New_York              1.6831065 -3.26534740   3.932216  -1.3184047  1.0773684
Oregon                1.6529194 -2.07884724   1.542711  -3.3202795 -0.7290467
                  cherryTRUE colaTRUE driedTRUE  noseTRUE  softTRUE  juicyTRUE
California          2.045379 4.123931  2.826463  1.846072 -1.585790 -1.7692667
Casablanca_Valley   2.021883 2.891076  2.768651  2.233732 -2.229882 -0.8354553
Marlborough         2.324624 4.676421  2.474280 -0.632064 -2.991824 -8.9713500
New_York            3.874359 2.013664  3.567936  1.368490 -1.724679 -2.5463012
Oregon              1.777277 4.839267  1.723301 -1.104719 -2.775285 -2.3068448
                     ripeTRUE  lightTRUE spicyTRUE     redTRUE     ageTRUE
California        -0.81774625 -1.0532169  1.743568 -2.00434039 -1.44999380
Casablanca_Valley -0.72422165 -2.1729740  2.544577 -0.94327475 -1.21012422
Marlborough       -1.62295402 -1.7742070 -1.056648 -2.93739351 -1.31354306
New_York           0.04775652 -2.5605727 -1.492944 -0.07849631 -0.96337152
Oregon            -1.45044987 -0.9071227  1.322941 -3.25791474 -0.03276851
                   bitTRUE tightTRUE cherriesTRUE   coreTRUE fruitsTRUE
California        1.967714 -1.467753    1.8029447 -0.9418752 -3.3181590
Casablanca_Valley 2.878874 -1.278929   -0.6114329 -1.4443096 -1.4400179
Marlborough       2.707458 -3.119091    3.8473412 -1.9291094 -3.7101744
New_York          3.113737 -4.263706    2.4750763  1.0239751 -4.5631192
Oregon            3.145447 -0.885478    2.1828054 -0.3947499 -0.4949466
                    richTRUE agingTRUE brightTRUE characterTRUE
California        -0.6855453 -4.086215  1.3340623     -2.153439
Casablanca_Valley -2.5142322 -2.982069  0.0507180     -2.116107
Marlborough       -1.4430898 -4.470252  2.0691414     -5.834644
New_York          -0.3290820 -1.285072  2.9191786     -2.563636
Oregon            -2.3326986 -1.931577  0.3737944     -2.635048
                  concentratedTRUE vintageTRUE complexTRUE estateTRUE  teaTRUE
California               1.4620805  -0.1012241 -0.18239771  0.7471917 3.788616
Casablanca_Valley        0.2357555   0.3845439 -1.67683776  1.1720331 4.272094
Marlborough             -0.1911979  -0.1456724  0.94191790 -3.2221563 0.257134
```

```
New_York                3.5023071  -2.4667464  0.36091202  0.1426499 1.738348
Oregon                  0.2231372   0.3432540 -0.02110645  1.0526559 2.655776
                    wildTRUE   firmTRUE  noirTRUE mediumTRUE structureTRUE
California         0.36587165 -0.8830966 0.5862657  1.3441821     -2.231292
Casablanca_Valley -0.08667357 -0.6666827 1.7229977 -1.7538364     -1.002573
Marlborough       -5.39089577 -1.5821823 1.5217391  2.3275299     -3.328536
New_York          -2.01806667 -1.9488939 3.3328402 -0.5876875     -3.888158
Oregon             0.02935259 -2.0077500 0.4596088  0.6494486     -3.676714
                   cloveTRUE   timeTRUE    freshTRUE balancedTRUE structuredTRUE
California          4.030044 -0.7866540 -0.313762895    0.2123106      -1.897127
Casablanca_Valley   2.424036 -0.1663997  0.548850168    0.5976676      -2.919778
Marlborough         3.132991 -1.3102947 -0.445204013   -2.2028568      -1.448782
New_York            1.889382 -0.9747153  0.004642212    0.1659371      -3.120470
Oregon              2.067396 -1.0542399 -0.183397685    0.2887585      -3.134053
                   orangeTRUE    plumTRUE pomegranateTRUE cinnamonTRUE
California           4.145574 -1.00369795        8.030843     2.954537
Casablanca_Valley    2.615550  2.35394615        7.002037     1.609312
Marlborough         -1.042343 -1.38485325        7.315746     1.707957
New_York             2.116361 -0.06534999        3.543369     2.702661
Oregon               3.372320 -0.66825529        6.067311     2.131381
                   savoryTRUE pepperTRUE  roseTRUE      points        year
California           4.781396   5.126222 2.9289451  0.84070572 0.011263065
Casablanca_Valley    4.556224   5.480111 0.1823699 -0.63148683 0.004320901
Marlborough          5.557808   4.673293 1.8198124  0.81931570 0.011543528
New_York             6.966426   2.930796 1.8367603 -0.03283032 0.007460148
Oregon               1.685422   5.078627 2.0875089  1.07523317 0.010061348
                   year_fold year_frecent    lprice price_flow price_fmed
California        -6.022472   -3.6719643 -3.969975 -1.9204502 -2.3529462
Casablanca_Valley -4.872445   -0.3158174 -4.158923 -0.3247519 -1.5250940
Marlborough       -3.285649   -0.1375306 -6.252223 -2.5110184 -0.8498381
New_York          -4.203493   -1.9243683 -5.463697 -0.1761111  0.3296439
Oregon            -2.879512   -1.5694764 -4.005269 -2.5947057 -2.0220379
                   cost_per_point
California          -5.062955e-05
Casablanca_Valley    5.390502e-03
Marlborough         -3.362881e-04
New_York             1.765178e-05
Oregon               1.620567e-04

Residual Deviance: 3646.722
AIC: 4486.722
```

```r
# Summarize the model
summary(model)
```

```
Call:
nnet::multinom(formula = province ~ ., data = train, trControl = control)

Coefficients:
                  (Intercept) bottlingTRUE  earthyTRUE herbalTRUE   berryTRUE
California        -2.04158110    2.3326692  2.33442850  2.6184997 -1.48538107
Casablanca_Valley -0.06739038    0.4766752  1.61014621  4.4720869  1.16357544
Marlborough        0.27853449    2.1998386 -0.05894852  2.8450814 -2.26217716
New_York          -0.05014946   -2.1480213  1.15189817  0.2317209  0.02374801
Oregon             1.42782315    1.3700733  0.98981926  2.6651440 -0.54422312
                  chocolateTRUE  drinkTRUE herbTRUE  oakTRUE tartTRUE
California         -0.166739656 -3.7928243 3.533443 3.913317 3.450648
Casablanca_Valley   3.226693701 -1.0833661 1.330802 4.491435 1.671139
Marlborough        -0.004645711  0.9308882 3.272825 3.564568 4.096477
New_York            0.782712010 -2.9616338 3.815811 2.849237 4.919106
Oregon              2.744276860 -2.2503736 3.724253 2.957143 4.056568
                  aromasTRUE bodiedTRUE earthTRUE forestTRUE offersTRUE
California         3.6439574  3.1391903  3.634394   4.343958  1.3704178
Casablanca_Valley  5.7297169  2.4463713  3.705557   1.514228  0.1120805
Marlborough        2.7851630  3.7523902  4.307556   4.403705  1.3266324
New_York           2.8690169  3.7222451  4.335826   2.696723 -0.8010808
Oregon             0.9459013  0.8677576  3.575171   2.224639  1.0973870
                  raspberryTRUE smoothTRUE  spiceTRUE textureTRUE finishTRUE
California            0.8460102  0.5293772 -0.1996805   0.8533104   1.414024
Casablanca_Valley     2.7819477  1.4035946  1.3082230  -2.8019570   3.185967
Marlborough          -0.7162472  1.2767656 -1.5948409   0.2435642   2.686562
New_York              1.3646539 -1.9712688  0.1666820  -1.7221301   2.646113
Oregon                0.6423684  0.7358623 -1.5175011  -1.7813671   1.682287
                  flavorTRUE   fruitTRUE notesTRUE  sweetTRUE touchTRUE
California         1.0873866 -1.26884697  2.294055  0.5982191 -1.853642
Casablanca_Valley  3.3747378 -1.22965762  3.837704  1.7436841 -2.219160
Marlborough       -0.4006780  0.02324362  4.152935 -1.0059028 -1.012609
New_York           0.9511496 -1.81661253  4.251899  1.2714178 -3.005321
Oregon             1.0969265  0.69160971  2.319266  0.9579421 -1.396591
                  flavorsTRUE tanninsTRUE fruityTRUE strawberryTRUE
California         -0.3409887  -1.6776045  -2.521548     -0.1487858
Casablanca_Valley   2.3344046  -2.8408571  -1.884170     -2.6385206
Marlborough        -0.4535177  -0.8731573  -6.202920     -3.3645528
New_York            0.4065842   1.4762037  -3.643402     -0.1588614
```

```
Oregon              0.8668873  -1.5327612  -1.850547     -0.5642598
                  cranberryTRUE    darkTRUE palateTRUE acidityTRUE  blackTRUE
California            2.2420927 -0.03308997   2.611196  -1.5886729  0.1379426
Casablanca_Valley     0.1972379 -1.19743158   3.870187  -0.6427209 -0.2267637
Marlborough           1.2378438 -0.77904225   2.386708  -5.0288805  0.1630800
New_York              1.6831065 -3.26534740   3.932216  -1.3184047  1.0773684
Oregon                1.6529194 -2.07884724   1.542711  -3.3202795 -0.7290467
                  cherryTRUE colaTRUE driedTRUE  noseTRUE  softTRUE  juicyTRUE
California          2.045379 4.123931  2.826463  1.846072 -1.585790 -1.7692667
Casablanca_Valley   2.021883 2.891076  2.768651  2.233732 -2.229882 -0.8354553
Marlborough         2.324624 4.676421  2.474280 -0.632064 -2.991824 -8.9713500
New_York            3.874359 2.013664  3.567936  1.368490 -1.724679 -2.5463012
Oregon              1.777277 4.839267  1.723301 -1.104719 -2.775285 -2.3068448
                     ripeTRUE  lightTRUE spicyTRUE     redTRUE     ageTRUE
California        -0.81774625 -1.0532169  1.743568 -2.00434039 -1.44999380
Casablanca_Valley -0.72422165 -2.1729740  2.544577 -0.94327475 -1.21012422
Marlborough       -1.62295402 -1.7742070 -1.056648 -2.93739351 -1.31354306
New_York           0.04775652 -2.5605727 -1.492944 -0.07849631 -0.96337152
Oregon            -1.45044987 -0.9071227  1.322941 -3.25791474 -0.03276851
                   bitTRUE tightTRUE cherriesTRUE   coreTRUE fruitsTRUE
California        1.967714 -1.467753    1.8029447 -0.9418752 -3.3181590
Casablanca_Valley 2.878874 -1.278929   -0.6114329 -1.4443096 -1.4400179
Marlborough       2.707458 -3.119091    3.8473412 -1.9291094 -3.7101744
New_York          3.113737 -4.263706    2.4750763  1.0239751 -4.5631192
Oregon            3.145447 -0.885478    2.1828054 -0.3947499 -0.4949466
                    richTRUE agingTRUE brightTRUE characterTRUE
California        -0.6855453 -4.086215  1.3340623     -2.153439
Casablanca_Valley -2.5142322 -2.982069  0.0507180     -2.116107
Marlborough       -1.4430898 -4.470252  2.0691414     -5.834644
New_York          -0.3290820 -1.285072  2.9191786     -2.563636
Oregon            -2.3326986 -1.931577  0.3737944     -2.635048
                  concentratedTRUE vintageTRUE complexTRUE estateTRUE  teaTRUE
California               1.4620805  -0.1012241 -0.18239771  0.7471917 3.788616
Casablanca_Valley        0.2357555   0.3845439 -1.67683776  1.1720331 4.272094
Marlborough             -0.1911979  -0.1456724  0.94191790 -3.2221563 0.257134
New_York                 3.5023071  -2.4667464  0.36091202  0.1426499 1.738348
Oregon                   0.2231372   0.3432540 -0.02110645  1.0526559 2.655776
                     wildTRUE   firmTRUE  noirTRUE mediumTRUE structureTRUE
California         0.36587165 -0.8830966 0.5862657  1.3441821     -2.231292
Casablanca_Valley -0.08667357 -0.6666827 1.7229977 -1.7538364     -1.002573
Marlborough       -5.39089577 -1.5821823 1.5217391  2.3275299     -3.328536
New_York          -2.01806667 -1.9488939 3.3328402 -0.5876875     -3.888158
Oregon             0.02935259 -2.0077500 0.4596088  0.6494486     -3.676714
```

```
                  cloveTRUE   timeTRUE    freshTRUE balancedTRUE structuredTRUE
California         4.030044 -0.7866540 -0.313762895    0.2123106      -1.897127
Casablanca_Valley  2.424036 -0.1663997  0.548850168    0.5976676      -2.919778
Marlborough        3.132991 -1.3102947 -0.445204013   -2.2028568      -1.448782
New_York           1.889382 -0.9747153  0.004642212    0.1659371      -3.120470
Oregon             2.067396 -1.0542399 -0.183397685    0.2887585      -3.134053
                  orangeTRUE    plumTRUE pomegranateTRUE cinnamonTRUE
California          4.145574 -1.00369795        8.030843     2.954537
Casablanca_Valley   2.615550  2.35394615        7.002037     1.609312
Marlborough        -1.042343 -1.38485325        7.315746     1.707957
New_York            2.116361 -0.06534999        3.543369     2.702661
Oregon              3.372320 -0.66825529        6.067311     2.131381
                  savoryTRUE pepperTRUE  roseTRUE      points        year
California          4.781396   5.126222 2.9289451  0.84070572 0.011263065
Casablanca_Valley   4.556224   5.480111 0.1823699 -0.63148683 0.004320901
Marlborough         5.557808   4.673293 1.8198124  0.81931570 0.011543528
New_York            6.966426   2.930796 1.8367603 -0.03283032 0.007460148
Oregon              1.685422   5.078627 2.0875089  1.07523317 0.010061348
                  year_fold year_frecent    lprice price_flow price_fmed
California        -6.022472   -3.6719643 -3.969975 -1.9204502 -2.3529462
Casablanca_Valley -4.872445   -0.3158174 -4.158923 -0.3247519 -1.5250940
Marlborough       -3.285649   -0.1375306 -6.252223 -2.5110184 -0.8498381
New_York          -4.203493   -1.9243683 -5.463697 -0.1761111  0.3296439
Oregon            -2.879512   -1.5694764 -4.005269 -2.5947057 -2.0220379
                  cost_per_point
California         -5.062955e-05
Casablanca_Valley   5.390502e-03
Marlborough        -3.362881e-04
New_York            1.765178e-05
Oregon              1.620567e-04

Std. Errors:
                   (Intercept) bottlingTRUE  earthyTRUE   herbalTRUE
California        1.634479e-04  0.052394740 0.087425374 0.0363635639
Casablanca_Valley 1.676385e-05  0.001271790 0.001825742 0.0020801923
Marlborough       5.958074e-05  0.002632244 0.002602181 0.0051086511
New_York          5.066043e-05  0.001044094 0.002409769 0.0005134238
Oregon            2.058716e-04  0.051364363 0.088170261 0.0403089271
                    berryTRUE chocolateTRUE   drinkTRUE     herbTRUE
California        0.064136265  0.0440677466 0.068699301 0.0643802852
Casablanca_Valley 0.002634178  0.0012903933 0.001424085 0.0003903905
Marlborough       0.002072363  0.0032988582 0.018499839 0.0034591942
New_York          0.004873782  0.0006566366 0.004318337 0.0022233629
```

```
Oregon            0.069587540  0.0500449153 0.095646979 0.0662974726
                      oakTRUE    tartTRUE  aromasTRUE  bodiedTRUE   earthTRUE
California        0.069268452 0.083538792 0.085418780 0.078350865 0.090175890
Casablanca_Valley 0.002073588 0.000700617 0.004830836 0.002417996 0.001139709
Marlborough       0.004564195 0.007936782 0.010612347 0.018201663 0.005658786
New_York          0.001609032 0.005362455 0.007514962 0.005054519 0.003358451
Oregon            0.069174192 0.085667168 0.072341724 0.058504371 0.089119778
                    forestTRUE  offersTRUE raspberryTRUE   smoothTRUE
California        0.0071824459 0.086546878   0.071161951 0.0438562050
Casablanca_Valley 0.0003904089 0.001803994   0.002773308 0.0008240811
Marlborough       0.0020332319 0.002815781   0.001108713 0.0027082168
New_York          0.0010685538 0.001030985   0.002891732 0.0007626984
Oregon            0.0069342564 0.087184574   0.070751962 0.0473971761
                    spiceTRUE  textureTRUE  finishTRUE  flavorTRUE   fruitTRUE
California        0.088299922 0.0583585202 0.060750868 0.082818300 0.053234492
Casablanca_Valley 0.003230738 0.0005398264 0.003058210 0.002061629 0.003174321
Marlborough       0.004517142 0.0092966641 0.009971967 0.003062029 0.016112477
New_York          0.006407289 0.0011794843 0.004784529 0.004054211 0.004280857
Oregon            0.082063163 0.0483610553 0.062781482 0.085813976 0.055922067
                    notesTRUE   sweetTRUE   touchTRUE flavorsTRUE  tanninsTRUE
California        0.088143394 0.020063123 0.072536445 0.054304749 0.0680145240
Casablanca_Valley 0.002303551 0.001237326 0.001574167 0.002499163 0.0009968369
Marlborough       0.008524827 0.001581028 0.003318576 0.010726800 0.0051289070
New_York          0.007581450 0.002198347 0.002021413 0.010414930 0.0094627171
Oregon            0.089069942 0.019489833 0.075883729 0.058922451 0.0741248602
                    fruityTRUE strawberryTRUE cranberryTRUE    darkTRUE
California        0.0138605700   0.0739145054   0.083671959 0.075147245
Casablanca_Valley 0.0007476780   0.0015922780   0.001321819 0.002038516
Marlborough       0.0006005338   0.0006845995   0.003582770 0.002004659
New_York          0.0009696406   0.0037714862   0.003717090 0.001362278
Oregon            0.0151037015   0.0744069349   0.083889781 0.074364459
                   palateTRUE acidityTRUE   blackTRUE  cherryTRUE     colaTRUE
California        0.070670352 0.075363693 0.066190248 0.055027559 0.0866522572
Casablanca_Valley 0.004570944 0.003628772 0.003442059 0.004737464 0.0013797354
Marlborough       0.007388107 0.003154068 0.015024837 0.011151672 0.0041831094
New_York          0.005789123 0.010127102 0.018242266 0.011356389 0.0009057516
Oregon            0.067990677 0.072719264 0.065577003 0.057321501 0.0860430284
                    driedTRUE    noseTRUE     softTRUE    juicyTRUE    ripeTRUE
California        0.051554713 0.072807994 0.0713812467 4.704839e-02 0.078908188
Casablanca_Valley 0.001583625 0.003652440 0.0008256454 1.645655e-03 0.002092487
Marlborough       0.002189518 0.004462424 0.0033216806 2.451663e-06 0.003855315
New_York          0.002549846 0.006267105 0.0029848355 1.459998e-03 0.006538688
Oregon            0.049923015 0.062906101 0.0730203891 4.694523e-02 0.080360227
```

```
                  lightTRUE   spicyTRUE     redTRUE      ageTRUE     bitTRUE
California        0.070740166 0.084757249 0.070596009 0.0110093766 0.044476202
Casablanca_Valley 0.001826404 0.002553907 0.002887191 0.0002126764 0.003245957
Marlborough       0.004613663 0.001046420 0.004671160 0.0020331523 0.005832009
New_York          0.004575486 0.001448208 0.005285194 0.0015564991 0.004835760
Oregon            0.074254200 0.084435746 0.070642668 0.0150616035 0.048951790
                     tightTRUE cherriesTRUE     coreTRUE   fruitsTRUE
California        0.0137648471 0.0417276017 0.0168389411 0.0225120544
Casablanca_Valley 0.0011496407 0.0002554425 0.0008984171 0.0018925371
Marlborough       0.0007924505 0.0092688314 0.0016806308 0.0002760635
New_York          0.0004642802 0.0033383315 0.0027109676 0.0005244626
Oregon            0.0138883309 0.0385912414 0.0163530445 0.0288134622
                     richTRUE    agingTRUE   brightTRUE characterTRUE
California        0.032563094 0.0080640195 0.0731548454  0.0123054255
Casablanca_Valley 0.001127559 0.0002028491 0.0009506553  0.0009984553
Marlborough       0.005769236 0.0007450727 0.0021157055  0.0004322819
New_York          0.006174692 0.0034056176 0.0029841075  0.0014413774
Oregon            0.028669278 0.0114296440 0.0728835819  0.0149504550
                  concentratedTRUE  vintageTRUE  complexTRUE   estateTRUE
California           0.0254375259 0.0269980872 0.0296893509 0.0475520696
Casablanca_Valley    0.0006158332 0.0006644211 0.0008293561 0.0004596304
Marlborough          0.0027885385 0.0025525187 0.0048318241 0.0023128133
New_York             0.0090976613 0.0001146065 0.0024648898 0.0017080222
Oregon               0.0249839717 0.0289054228 0.0286374867 0.0489981688
                        teaTRUE     wildTRUE     firmTRUE    noirTRUE
California        0.040131352 2.629022e-02 0.0194399869 0.077054041
Casablanca_Valley 0.001164220 7.399204e-04 0.0005288864 0.002159728
Marlborough       0.001483994 4.972246e-06 0.0030811002 0.011101906
New_York          0.002166048 1.834868e-03 0.0043680912 0.005146611
Oregon            0.039307640 2.598851e-02 0.0177498892 0.084000219
                    mediumTRUE structureTRUE    cloveTRUE    timeTRUE
California        0.0542876074   0.011799151 0.0145411629 0.019628872
Casablanca_Valley 0.0006773466   0.001082429 0.0004942463 0.001034494
Marlborough       0.0173721012   0.001748053 0.0023750159 0.001457243
New_York          0.0051866886   0.001962556 0.0002785856 0.001207018
Oregon            0.0414120961   0.013802460 0.0141356492 0.019835518
                    freshTRUE balancedTRUE structuredTRUE   orangeTRUE
California        0.089374464 0.0583193980   0.0075392630 2.863345e-02
Casablanca_Valley 0.001775204 0.0009750446   0.0003891031 4.827532e-04
Marlborough       0.002848773 0.0006892599   0.0027826070 1.121624e-05
New_York          0.004776672 0.0020740649   0.0020204403 2.841666e-04
Oregon            0.088688224 0.0605854522   0.0075273954 2.854065e-02
                     plumTRUE pomegranateTRUE cinnamonTRUE  savoryTRUE
```

```
California        0.085474092    0.0135731389 0.0441136844 0.008312937
Casablanca_Valley 0.005358577    0.0004627147 0.0008384968 0.001195433
Marlborough       0.004248676    0.0018608029 0.0029961260 0.004520740
New_York          0.006522145    0.0004065871 0.0029389604 0.003038904
Oregon            0.081921878    0.0126719338 0.0412596727 0.006260571
                  pepperTRUE     roseTRUE     points         year
California        0.0253466800 0.0445321159 0.06241054 1.492347e-04
Casablanca_Valley 0.0009147281 0.0003362797 0.01742825 1.244470e-04
Marlborough       0.0016924811 0.0022227267 0.09411294 9.215964e-05
New_York          0.0010552841 0.0015544688 0.07576594 1.052954e-04
Oregon            0.0248518904 0.0437173069 0.06119419 1.522296e-04
                     year_fold year_frecent      lprice  price_flow  price_fmed
California        0.0116773763  0.060203172 0.070489768 0.042693283 0.064024158
Casablanca_Valley 0.0009064389  0.005128182 0.006597021 0.003086840 0.003735262
Marlborough       0.0041831428  0.019696189 0.028132555 0.007248148 0.013349257
New_York          0.0039724815  0.009046872 0.023875117 0.010888515 0.005872906
Oregon            0.0148564855  0.086814898 0.069301519 0.036211798 0.059838905
                  cost_per_point
California          0.0007707637
Casablanca_Valley   0.0011653763
Marlborough         0.0011428836
New_York            0.0012912795
Oregon              0.0007446660

Residual Deviance: 3646.722
AIC: 4486.722
```

```r
# Make predictions
preds <- predict(model, type="class", newdata=test)

head(preds)
```

```
[1] Oregon   Oregon   Oregon   Oregon   Burgundy Oregon
6 Levels: Burgundy California Casablanca_Valley Marlborough ... Oregon
```

```r
postResample(test$province,preds)
```

```
 Accuracy     Kappa
0.8804543 0.8145531
```

```
predictors(model)
```

```
 [1] "bottling"       "earthy"         "herbal"         "berry"
 [5] "chocolate"      "drink"          "herb"           "oak"
 [9] "tart"           "aromas"         "bodied"         "earth"
[13] "forest"         "offers"         "raspberry"      "smooth"
[17] "spice"          "texture"        "finish"         "flavor"
[21] "fruit"          "notes"          "sweet"          "touch"
[25] "flavors"        "tannins"        "fruity"         "strawberry"
[29] "cranberry"      "dark"           "palate"         "acidity"
[33] "black"          "cherry"         "cola"           "dried"
[37] "nose"           "soft"           "juicy"          "ripe"
[41] "light"          "spicy"          "red"            "age"
[45] "bit"            "tight"          "cherries"       "core"
[49] "fruits"         "rich"           "aging"          "bright"
[53] "character"      "concentrated"   "vintage"        "complex"
[57] "estate"         "tea"            "wild"           "firm"
[61] "noir"           "medium"         "structure"      "clove"
[65] "time"           "fresh"          "balanced"       "structured"
[69] "orange"         "plum"           "pomegranate"    "cinnamon"
[73] "savory"         "pepper"         "rose"           "points"
[77] "year"           "year_f"         "lprice"         "price_f"
[81] "cost_per_point"
```

```
varImp(model)%>%
  arrange(desc(Overall))
```

```
                    Overall
pomegranateTRUE  31.959304191
lprice           23.850087811
savoryTRUE       23.547277352
pepperTRUE       23.289049038
year_fold        21.263571327
earthTRUE        19.558503049
colaTRUE         18.544359354
tartTRUE         18.193937972
oakTRUE          17.775700905
notesTRUE        16.855859307
juicyTRUE        16.429217979
fruityTRUE       16.102586395
```

```
aromasTRUE       15.973755418
herbTRUE         15.677134439
characterTRUE    15.302873079
forestTRUE       15.183254031
agingTRUE        14.755185444
palateTRUE       14.343019231
structureTRUE    14.127273001
bodiedTRUE       13.927954473
bitTRUE          13.813231368
cloveTRUE        13.543849335
fruitsTRUE       13.526417204
driedTRUE        13.360631088
orangeTRUE       13.292147137
herbalTRUE       12.832532875
teaTRUE          12.711967210
structuredTRUE   12.520209495
cherryTRUE       12.043522523
acidityTRUE      11.898958413
finishTRUE       11.614953459
softTRUE         11.307460565
cinnamonTRUE     11.105847688
drinkTRUE        11.019086079
tightTRUE        11.014957054
cherriesTRUE     10.919600554
touchTRUE         9.487323060
redTRUE           9.221419710
roseTRUE          8.855396655
bottlingTRUE      8.527277577
lightTRUE         8.468093337
tanninsTRUE       8.400583928
spicyTRUE         8.160678692
wildTRUE          7.890860253
noirTRUE          7.623451525
year_frecent      7.619157019
price_flow        7.527037338
textureTRUE       7.402328892
darkTRUE          7.353758444
richTRUE          7.304647876
noseTRUE          7.185077581
firmTRUE          7.088605393
price_fmed        7.079560067
cranberryTRUE     7.013200314
chocolateTRUE     6.925067938
```

```
flavorTRUE         6.910878338
strawberryTRUE     6.874980417
brightTRUE         6.746894715
mediumTRUE         6.662684592
raspberryTRUE      6.351227509
estateTRUE         6.336686848
earthyTRUE         6.145240673
smoothTRUE         5.916868534
coreTRUE           5.734019219
concentratedTRUE   5.614478136
sweetTRUE          5.577165824
berryTRUE          5.479104796
plumTRUE           5.476102631
fruitTRUE          5.029970462
ageTRUE            4.969801105
spiceTRUE          4.786927595
offersTRUE         4.707598594
ripeTRUE           4.663128312
flavorsTRUE        4.402382535
timeTRUE           4.292303707
balancedTRUE       3.467530639
vintageTRUE        3.441440785
points             3.399571733
complexTRUE        3.183171843
blackTRUE          2.334201500
freshTRUE          1.495856974
year               0.044648990
cost_per_point     0.005957128
```

```
confusionMatrix(predict(model, test),factor(test$province))
```

```
Confusion Matrix and Statistics

                  Reference
Prediction          Burgundy California Casablanca_Valley Marlborough New_York
  Burgundy               221          7                 0           1        0
  California               2        720                 4           2        7
  Casablanca_Valley        1          1                20           0        0
  Marlborough              0          2                 0          32        0
  New_York                 0          7                 0           0       17
  Oregon                  14         54                 2          10        2
```

```
                  Reference
Prediction          Oregon
  Burgundy              10
  California            70
  Casablanca_Valley      1
  Marlborough            3
  New_York               0
  Oregon               463

Overall Statistics

               Accuracy : 0.8805
                 95% CI : (0.8639, 0.8956)
    No Information Rate : 0.4728
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.8146

 Mcnemar's Test P-Value : NA

Statistics by Class:

                     Class: Burgundy Class: California Class: Casablanca_Valley
Sensitivity                   0.9286            0.9102                  0.76923
Specificity                   0.9875            0.9036                  0.99818
Pos Pred Value                0.9247            0.8944                  0.86957
Neg Pred Value                0.9881            0.9182                  0.99636
Prevalence                    0.1423            0.4728                  0.01554
Detection Rate                0.1321            0.4304                  0.01195
Detection Prevalence          0.1429            0.4812                  0.01375
Balanced Accuracy             0.9580            0.9069                  0.88370
                     Class: Marlborough Class: New_York Class: Oregon
Sensitivity                     0.71111         0.65385        0.8464
Specificity                     0.99693         0.99575        0.9272
Pos Pred Value                  0.86486         0.70833        0.8495
Neg Pred Value                  0.99205         0.99454        0.9255
Prevalence                      0.02690         0.01554        0.3270
Detection Rate                  0.01913         0.01016        0.2767
Detection Prevalence            0.02212         0.01435        0.3258
Balanced Accuracy               0.85402         0.82480        0.8868
```

Elastic Net Regression

```
# install.packages("devtools")
# install.packages("glmnet", repos = "https://cran.us.r-project.org")

library(glmnet)
```

```
Loading required package: Matrix
```

```

Attaching package: 'Matrix'
```

```
The following objects are masked from 'package:tidyr':

    expand, pack, unpack
```

```
Loaded glmnet 4.1-6
```

```
custom <- trainControl(method =  "cv",
                       number = 5)
```

```
#fitting Elastic Net Regression model

set.seed(100)
en <- train(province~.,
            train,
            method='glmnet',
            tuneGrid =expand.grid(alpha=seq(0,1,length=10),
                                  lambda = seq(0.0001,0.2,length=20)),
            trControl=custom)
```

```
# Best tuning parameter
en$bestTune
```

```
      alpha lambda
81 0.4444444  1e-04
```

```
varImp(en)
```

```
glmnet variable importance

  variables are sorted by maximum importance across the classes
  only 20 most important variables shown (out of 83)

                Burgundy California Casablanca_Valley Marlborough New_York
pomegranateTRUE   100.000     58.947            0.0000    41.38975  42.8323
savoryTRUE         95.513     11.177            0.0000    23.00881  55.9192
earthTRUE          89.087      0.000            8.0363    10.75077  15.3965
pepperTRUE         83.189      9.286           20.2740     0.00000  33.4751
aromasTRUE         49.450     16.501           79.7748     0.92571   0.0000
mediumTRUE          0.000     19.204           77.8105    35.00506  16.4818
plumTRUE            0.000     15.655           71.5402    21.62004   6.4094
driedTRUE          71.295      8.180            1.1756     0.00000  23.7745
flavorTRUE         18.784      0.000           69.8040    22.30780   0.8463
colaTRUE           66.039     18.755            0.0000    30.15019  25.0246
tartTRUE           65.442      0.000           47.0909    12.02267  32.4463
herbTRUE           64.578      3.002           56.7534     0.00000   7.6601
roseTRUE           46.090     22.463           62.5382     0.04414   0.0000
bottlingTRUE       17.992     42.179           20.7112    35.26934  62.1365
lprice             62.032      1.333            0.0000    34.20603  31.3851
juicyTRUE          36.154      5.553           29.4033    61.87150   5.0896
flavorsTRUE         8.464     14.841           59.4246    15.02789   0.0000
cherriesTRUE       32.196      0.000           58.2617    37.35467   9.7043
tightTRUE          27.902      0.000            0.4308    22.96196  58.1728
concentratedTRUE   11.779     14.771            0.0000    11.27562  58.0967
                  Oregon
pomegranateTRUE  22.2793
savoryTRUE       46.1928
earthTRUE         2.0098
pepperTRUE        8.0214
aromasTRUE       35.1750
mediumTRUE        5.8991
plumTRUE          9.3955
driedTRUE        13.3203
flavorTRUE        1.0492
colaTRUE         32.8219
tartTRUE         11.9329
herbTRUE          6.7975
roseTRUE          6.0345
```

```
bottlingTRUE     23.3917
lprice            0.3102
juicyTRUE         4.1488
flavorsTRUE       8.1647
cherriesTRUE      7.6878
tightTRUE        11.1448
concentratedTRUE  9.2506
```

```
confusionMatrix(predict(en, test),factor(test$province))
```

```
Confusion Matrix and Statistics

                  Reference
Prediction          Burgundy California Casablanca_Valley Marlborough New_York
  Burgundy               221          6                 0           1        0
  California               2        723                 4           2        7
  Casablanca_Valley        1          2                20           0        1
  Marlborough              0          2                 0          31        1
  New_York                 0          4                 0           1       16
  Oregon                  14         54                 2          10        1
                  Reference
Prediction          Oregon
  Burgundy               9
  California            67
  Casablanca_Valley      1
  Marlborough            3
  New_York               0
  Oregon               467

Overall Statistics

               Accuracy : 0.8834
                 95% CI : (0.8671, 0.8984)
    No Information Rate : 0.4728
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.8191

 Mcnemar's Test P-Value : NA

Statistics by Class:
```

	Class: Burgundy	Class: California	Class: Casablanca_Valley
Sensitivity	0.9286	0.9140	0.76923
Specificity	0.9889	0.9070	0.99696
Pos Pred Value	0.9325	0.8981	0.80000
Neg Pred Value	0.9882	0.9217	0.99636
Prevalence	0.1423	0.4728	0.01554
Detection Rate	0.1321	0.4322	0.01195
Detection Prevalence	0.1417	0.4812	0.01494
Balanced Accuracy	0.9587	0.9105	0.88310

	Class: Marlborough	Class: New_York	Class: Oregon
Sensitivity	0.68889	0.615385	0.8537
Specificity	0.99631	0.996964	0.9281
Pos Pred Value	0.83784	0.761905	0.8522
Neg Pred Value	0.99144	0.993947	0.9289
Prevalence	0.02690	0.015541	0.3270
Detection Rate	0.01853	0.009564	0.2791
Detection Prevalence	0.02212	0.012552	0.3276
Balanced Accuracy	0.84260	0.806174	0.8909