Naive Bayes Agency Data Predictive Model

Frank Neugebauer

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Agency Data Simple Naive Bayes Predictive Model

Agency data intuitively has value to an agency and potentially to agent's carrier partner(s). One way to gain value from that data - which exists within agency management systems - is to create one or more predictive models. Gaining insight from predictive modeling using agency data is the fundamental nature of this effort.

Epilogue It's clear that predictive modelling with agency has value. The contents of this analysis are a single perspective of such an effort, although subsequently, at least one other perspective is presented to give the reader a glimpse into how varied this analysis could potentially be.

This uses a largely unaltered simple Naive Bayes model to set a baseline for subsequent predictive models, which can be created using other algorithms.

```
# Read the original data set
agency_data_orig <- read.xlsx('./data/AgencyData_clean.xlsx', sheetIndex=1, stringsAsFactors=T)
```

Data Setup

There are a couple of irrelevant attributes from the original set. Get rid of those and then setup the `train` and `test` data sets.

```
# Trim the phat - i.e., data that's irrelevant
agency_data_used <- agency_data_orig[c(-1, -4)]
str(agency_data_used)
```

```
## 'data.frame':    2376 obs. of  12 variables:
##  $ account_type    : Factor w/ 2 levels "Commercial","Personal": 2 2 2 2 2 2 2 2 2 2 ...
##  $ assigned_agent  : Factor w/ 6 levels "Boehm, Sebastian",..: 6 2 2 6 6 6 6 6 6 6 ...
##  $ lob             : Factor w/ 20 levels "Auto (Commercial)",..: 10 10 2 10 2 2 10 7 2 2 ...
##  $ master_company  : Factor w/ 20 levels "Aimonetti Insurance",..: 9 9 9 9 9 9 9 11 9 9 ...
##  $ effective_date  : Date, format: "2014-10-07" "2014-10-06" ...
##  $ policy_term     : Factor w/ 3 levels "12 Months","6 Months",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ policy_type     : Factor w/ 2 levels "Commercial","Personal": 2 2 2 2 2 2 2 2 2 2 ...
##  $ annual_premium  : num  291 868 1239 789 1648 ...
##  $ written_premium : num  291 868 1239 789 1648 ...
##  $ rating_state    : Factor w/ 8 levels "FL","ND","NV",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ status          : Factor w/ 2 levels "Active","Inactive": 2 2 2 2 2 2 2 2 2 2 ...
##  $ transaction_type: Factor w/ 13 levels "Cancel Conf",..: 13 13 13 13 13 13 13 5 13 13 ...
```

```
# Setup train and test data, 70% / 30%
train_ad <- sample_frac(agency_data_used, 0.7)
sid <- as.numeric(rownames(train_ad)) # because rownames() returns character
test_ad <- agency_data_used[-sid,]
```

Build the Model

This step is set aside because with a big data set, it would be slow or put into a distributed system. This model is using `transaction_type` as the target variable. In simple terms, the model is making predictions for the various transaction types given other conditions, such as the line of business.

For example, can the model predict the likelihood of a renewal for a personal auto policy (it can go deeper than that, but it's a good illustration of the principle).

```
nb_model <- naiveBayes(transaction_type~., data=train_ad)
```

Conditional Probabilities

The model creates the conditional probabilities based on the training data. This output shows those, which is interesting unto itself.

Intuitively, it may appear that this is simple math - e.g., if there were 100 transactions and 40 of them were renewals, then the probability should be 40%. However, this model is multi-factored, which means a more accurate way of considering it is, given the line of business was personal auto, there's some non-obvious probability that a renwal will occur. That's the kind of probabilities being reported here.

```
nb_model$tables$assigned_agent
```

```
##                     assigned_agent
## Y                    Boehm, Sebastian Doyle, Walter Insurance, Nichersen
##    Cancel Conf            0.111271676    0.420520231        0.057803468
##    Cancel Req             0.000000000    0.800000000        0.000000000
##    Cancel/DNR             0.250000000    0.000000000        0.750000000
##    DB Synch               0.000000000    0.250000000        0.500000000
##    New Business           0.084745763    0.401129944        0.000000000
##    Non-Renewal            0.000000000    0.000000000        0.000000000
##    Policy Change          0.129198966    0.364341085        0.002583979
##    Re-Issue               0.000000000    0.000000000        0.000000000
##    Reinstate              0.093023256    0.325581395        0.023255814
##    Renew Quote            0.000000000    1.000000000        0.000000000
##    Renewal                0.247678019    0.414860681        0.000000000
##    Renewal Re-Quote       0.500000000    0.000000000        0.000000000
##    Rewrite                0.130434783    0.304347826        0.000000000
##                     assigned_agent
## Y                    Padberg, Tracy Rohan, Elwood Tremblay, Deena
##    Cancel Conf          0.014450867   0.011560694     0.384393064
##    Cancel Req           0.000000000   0.000000000     0.200000000
##    Cancel/DNR           0.000000000   0.000000000     0.000000000
##    DB Synch             0.250000000   0.000000000     0.000000000
##    New Business         0.186440678   0.067796610     0.259887006
##    Non-Renewal          0.000000000   0.000000000     1.000000000
##    Policy Change        0.124031008   0.067183463     0.312661499
##    Re-Issue             0.000000000   0.000000000     1.000000000
##    Reinstate            0.046511628   0.209302326     0.302325581
##    Renew Quote          0.000000000   0.000000000     0.000000000
##    Renewal              0.009287926   0.012383901     0.315789474
##    Renewal Re-Quote     0.000000000   0.000000000     0.500000000
##    Rewrite              0.000000000   0.000000000     0.565217391
```

```
nb_model$tables$lob
```

```
##               lob
## Y              Auto (Commercial) Auto (Personal) BOP Liability
##    Cancel Conf       0.008670520     0.712427746   0.001445087
##    Cancel Req        0.200000000     0.800000000   0.000000000
##    Cancel/DNR        0.000000000     1.000000000   0.000000000
##    DB Synch          0.000000000     1.000000000   0.000000000
```

```
##    New Business         0.016949153      0.237288136      0.005649718
##    Non-Renewal          0.000000000      1.000000000      0.000000000
##    Policy Change        0.007751938      0.713178295      0.000000000
##    Re-Issue             0.000000000      1.000000000      0.000000000
##    Reinstate            0.000000000      0.674418605      0.000000000
##    Renew Quote          0.000000000      1.000000000      0.000000000
##    Renewal              0.015479876      0.572755418      0.000000000
##    Renewal Re-Quote     0.000000000      1.000000000      0.000000000
##    Rewrite              0.000000000      0.608695652      0.000000000
##                  lob
## Y             BOP Property Business Owners Policy Commercial Prpty
##    Cancel Conf      0.001445087           0.005780347      0.001445087
##    Cancel Req       0.000000000           0.000000000      0.000000000
##    Cancel/DNR       0.000000000           0.000000000      0.000000000
##    DB Synch         0.000000000           0.000000000      0.000000000
##    New Business     0.000000000           0.028248588      0.005649718
##    Non-Renewal      0.000000000           0.000000000      0.000000000
##    Policy Change    0.000000000           0.002583979      0.000000000
##    Re-Issue         0.000000000           0.000000000      0.000000000
##    Reinstate        0.000000000           0.000000000      0.000000000
##    Renew Quote      0.000000000           0.000000000      0.000000000
##    Renewal          0.000000000           0.009287926      0.006191950
##    Renewal Re-Quote 0.000000000           0.000000000      0.000000000
##    Rewrite          0.000000000           0.000000000      0.000000000
##                  lob
## Y             Dwelling fire      Flood Genl Liability  Homeowners
##    Cancel Conf      0.015895954 0.000000000   0.014450867 0.231213873
##    Cancel Req       0.000000000 0.000000000   0.000000000 0.000000000
##    Cancel/DNR       0.000000000 0.000000000   0.000000000 0.000000000
##    DB Synch         0.000000000 0.000000000   0.000000000 0.000000000
##    New Business     0.028248588 0.000000000   0.056497175 0.519774011
##    Non-Renewal      0.000000000 0.000000000   0.000000000 0.000000000
##    Policy Change    0.028423773 0.002583979   0.000000000 0.229974160
##    Re-Issue         0.000000000 0.000000000   0.000000000 0.000000000
##    Reinstate        0.046511628 0.000000000   0.000000000 0.255813953
##    Renew Quote      0.000000000 0.000000000   0.000000000 0.000000000
##    Renewal          0.018575851 0.000000000   0.034055728 0.312693498
##    Renewal Re-Quote 0.000000000 0.000000000   0.000000000 0.000000000
##    Rewrite          0.000000000 0.000000000   0.000000000 0.391304348
##                  lob
## Y             Inland marine (comm) Inland Marine (pers)
##    Cancel Conf          0.000000000          0.001445087
##    Cancel Req           0.000000000          0.000000000
##    Cancel/DNR           0.000000000          0.000000000
##    DB Synch             0.000000000          0.000000000
##    New Business         0.000000000          0.000000000
##    Non-Renewal          0.000000000          0.000000000
##    Policy Change        0.000000000          0.000000000
##    Re-Issue             0.000000000          0.000000000
##    Reinstate            0.000000000          0.000000000
##    Renew Quote          0.000000000          0.000000000
##    Renewal              0.015479876          0.003095975
##    Renewal Re-Quote     0.000000000          0.000000000
##    Rewrite              0.000000000          0.000000000
```

```
##                 lob
## Y               Personal Liability Professional Liab     Renters
##   Cancel Conf            0.000000000        0.000000000 0.000000000
##   Cancel Req             0.000000000        0.000000000 0.000000000
##   Cancel/DNR             0.000000000        0.000000000 0.000000000
##   DB Synch               0.000000000        0.000000000 0.000000000
##   New Business           0.005649718        0.011299435 0.000000000
##   Non-Renewal            0.000000000        0.000000000 0.000000000
##   Policy Change          0.000000000        0.000000000 0.000000000
##   Re-Issue               0.000000000        0.000000000 0.000000000
##   Reinstate              0.000000000        0.000000000 0.000000000
##   Renew Quote            0.000000000        0.000000000 0.000000000
##   Renewal                0.000000000        0.000000000 0.000000000
##   Renewal Re-Quote       0.000000000        0.000000000 0.000000000
##   Rewrite                0.000000000        0.000000000 0.000000000
##                 lob
## Y                   Signs Umbrella - Comm Umbrella - Personal
##   Cancel Conf      0.000000000     0.001445087        0.002890173
##   Cancel Req       0.000000000     0.000000000        0.000000000
##   Cancel/DNR       0.000000000     0.000000000        0.000000000
##   DB Synch         0.000000000     0.000000000        0.000000000
##   New Business     0.000000000     0.005649718        0.056497175
##   Non-Renewal      0.000000000     0.000000000        0.000000000
##   Policy Change    0.002583979     0.000000000        0.012919897
##   Re-Issue         0.000000000     0.000000000        0.000000000
##   Reinstate        0.000000000     0.000000000        0.023255814
##   Renew Quote      0.000000000     0.000000000        0.000000000
##   Renewal          0.000000000     0.000000000        0.012383901
##   Renewal Re-Quote 0.000000000     0.000000000        0.000000000
##   Rewrite          0.000000000     0.000000000        0.000000000
##                 lob
## Y               Watercraft (small boat) Workers comp
##   Cancel Conf                0.000000000  0.001445087
##   Cancel Req                 0.000000000  0.000000000
##   Cancel/DNR                 0.000000000  0.000000000
##   DB Synch                   0.000000000  0.000000000
##   New Business               0.016949153  0.005649718
##   Non-Renewal                0.000000000  0.000000000
##   Policy Change              0.000000000  0.000000000
##   Re-Issue                   0.000000000  0.000000000
##   Reinstate                  0.000000000  0.000000000
##   Renew Quote                0.000000000  0.000000000
##   Renewal                    0.000000000  0.000000000
##   Renewal Re-Quote           0.000000000  0.000000000
##   Rewrite                    0.000000000  0.000000000
```

nb_model$tables$master_company

```
##                 master_company
## Y                Aimonetti Insurance Beaulah General Agency
##   Cancel Conf           0.338150289              0.000000000
##   Cancel Req            1.000000000              0.000000000
##   Cancel/DNR            0.250000000              0.000000000
##   DB Synch              0.750000000              0.000000000
##   New Business          0.135593220              0.005649718
```

```
##    Non-Renewal              0.000000000             0.000000000
##    Policy Change            0.354005168             0.000000000
##    Re-Issue                 1.000000000             0.000000000
##    Reinstate                0.441860465             0.000000000
##    Renew Quote              1.000000000             0.000000000
##    Renewal                  0.297213622             0.003095975
##    Renewal Re-Quote         1.000000000             0.000000000
##    Rewrite                  0.043478261             0.000000000
##             master_company
## Y          Beaulah Insurance Beyer Strategic Insurance
##    Cancel Conf              0.079479769             0.056358382
##    Cancel Req               0.000000000             0.000000000
##    Cancel/DNR               0.000000000             0.000000000
##    DB Synch                 0.000000000             0.000000000
##    New Business             0.011299435             0.084745763
##    Non-Renewal              0.000000000             0.000000000
##    Policy Change            0.049095607             0.038759690
##    Re-Issue                 0.000000000             0.000000000
##    Reinstate                0.023255814             0.046511628
##    Renew Quote              0.000000000             0.000000000
##    Renewal                  0.092879257             0.046439628
##    Renewal Re-Quote         0.000000000             0.000000000
##    Rewrite                  0.086956522             0.000000000
##             master_company
## Y          Borer Group, LLC Brakus Fire & Casualty
##    Cancel Conf              0.005780347             0.001445087
##    Cancel Req               0.000000000             0.000000000
##    Cancel/DNR               0.000000000             0.000000000
##    DB Synch                 0.000000000             0.000000000
##    New Business             0.084745763             0.000000000
##    Non-Renewal              0.000000000             0.000000000
##    Policy Change            0.043927649             0.000000000
##    Re-Issue                 0.000000000             0.000000000
##    Reinstate                0.023255814             0.000000000
##    Renew Quote              0.000000000             0.000000000
##    Renewal                  0.000000000             0.000000000
##    Renewal Re-Quote         0.000000000             0.000000000
##    Rewrite                  0.086956522             0.000000000
##             master_company
## Y          Breitenberg Insurance DuBuque Insurance
##    Cancel Conf              0.170520231             0.095375723
##    Cancel Req               0.000000000             0.000000000
##    Cancel/DNR               0.500000000             0.000000000
##    DB Synch                 0.250000000             0.000000000
##    New Business             0.073446328             0.180790960
##    Non-Renewal              1.000000000             0.000000000
##    Policy Change            0.069767442             0.155038760
##    Re-Issue                 0.000000000             0.000000000
##    Reinstate                0.023255814             0.139534884
##    Renew Quote              0.000000000             0.000000000
##    Renewal                  0.170278638             0.027863777
##    Renewal Re-Quote         0.000000000             0.000000000
##    Rewrite                  0.000000000             0.130434783
##             master_company
```

```
## Y                  Friesen Insurance Helen Herman Group Hui Insurance
##   Cancel Conf            0.039017341        0.004335260  0.017341040
##   Cancel Req             0.000000000        0.000000000  0.000000000
##   Cancel/DNR             0.000000000        0.000000000  0.000000000
##   DB Synch               0.000000000        0.000000000  0.000000000
##   New Business           0.005649718        0.000000000  0.186440678
##   Non-Renewal            0.000000000        0.000000000  0.000000000
##   Policy Change          0.056847545        0.002583979  0.064599483
##   Re-Issue               0.000000000        0.000000000  0.000000000
##   Reinstate              0.046511628        0.000000000  0.046511628
##   Renew Quote            0.000000000        0.000000000  0.000000000
##   Renewal                0.052631579        0.006191950  0.030959752
##   Renewal Re-Quote       0.000000000        0.000000000  0.000000000
##   Rewrite                0.391304348        0.000000000  0.130434783
##                  master_company
## Y                  Kilback Excess & Surplus Roderick Insurance
##   Cancel Conf                   0.000000000       0.005780347
##   Cancel Req                    0.000000000       0.000000000
##   Cancel/DNR                    0.000000000       0.000000000
##   DB Synch                      0.000000000       0.000000000
##   New Business                  0.028248588       0.062146893
##   Non-Renewal                   0.000000000       0.000000000
##   Policy Change                 0.000000000       0.064599483
##   Re-Issue                      0.000000000       0.000000000
##   Reinstate                     0.000000000       0.069767442
##   Renew Quote                   0.000000000       0.000000000
##   Renewal                       0.000000000       0.092879257
##   Renewal Re-Quote              0.000000000       0.000000000
##   Rewrite                       0.000000000       0.000000000
##                  master_company
## Y                  Ryan Hyatt Insurance Schimel Mutual Insurance
##   Cancel Conf               0.007225434               0.021676301
##   Cancel Req                0.000000000               0.000000000
##   Cancel/DNR                0.000000000               0.000000000
##   DB Synch                  0.000000000               0.000000000
##   New Business              0.011299435               0.050847458
##   Non-Renewal               0.000000000               0.000000000
##   Policy Change             0.002583979               0.000000000
##   Re-Issue                  0.000000000               0.000000000
##   Reinstate                 0.023255814               0.000000000
##   Renew Quote               0.000000000               0.000000000
##   Renewal                   0.000000000               0.058823529
##   Renewal Re-Quote          0.000000000               0.000000000
##   Rewrite                   0.000000000               0.000000000
##                  master_company
## Y                  Schuppe Group Simonis Insurance Spinka West Insurance
##   Cancel Conf      0.067919075       0.044797688            0.034682081
##   Cancel Req       0.000000000       0.000000000            0.000000000
##   Cancel/DNR       0.250000000       0.000000000            0.000000000
##   DB Synch         0.000000000       0.000000000            0.000000000
##   New Business     0.045197740       0.022598870            0.000000000
##   Non-Renewal      0.000000000       0.000000000            0.000000000
##   Policy Change    0.069767442       0.005167959            0.010335917
##   Re-Issue         0.000000000       0.000000000            0.000000000
```

```
##    Reinstate           0.000000000        0.023255814            0.023255814
##    Renew Quote         0.000000000        0.000000000            0.000000000
##    Renewal             0.077399381        0.015479876            0.012383901
##    Renewal Re-Quote    0.000000000        0.000000000            0.000000000
##    Rewrite             0.130434783        0.000000000            0.000000000
##                    master_company
## Y               Streich Group Insurance Sultan Insurance
##    Cancel Conf                0.010115607        0.000000000
##    Cancel Req                 0.000000000        0.000000000
##    Cancel/DNR                 0.000000000        0.000000000
##    DB Synch                   0.000000000        0.000000000
##    New Business               0.011299435        0.000000000
##    Non-Renewal                0.000000000        0.000000000
##    Policy Change              0.012919897        0.000000000
##    Re-Issue                   0.000000000        0.000000000
##    Reinstate                  0.069767442        0.000000000
##    Renew Quote                0.000000000        0.000000000
##    Renewal                    0.015479876        0.000000000
##    Renewal Re-Quote           0.000000000        0.000000000
##    Rewrite                    0.000000000        0.000000000
```

```
#nb_model$tables$effective_date # bin this
nb_model$tables$policy_term
```

```
##                    policy_term
## Y                12 Months   6 Months   7 Months
##    Cancel Conf     0.55924855 0.44075145 0.00000000
##    Cancel Req      0.40000000 0.60000000 0.00000000
##    Cancel/DNR      0.25000000 0.75000000 0.00000000
##    DB Synch        0.50000000 0.50000000 0.00000000
##    New Business    0.96045198 0.03954802 0.00000000
##    Non-Renewal     1.00000000 0.00000000 0.00000000
##    Policy Change   0.84496124 0.15503876 0.00000000
##    Re-Issue        1.00000000 0.00000000 0.00000000
##    Reinstate       0.69767442 0.30232558 0.00000000
##    Renew Quote     0.00000000 1.00000000 0.00000000
##    Renewal         0.75851393 0.24148607 0.00000000
##    Renewal Re-Quote 0.50000000 0.50000000 0.00000000
##    Rewrite         0.95652174 0.04347826 0.00000000
```

```
nb_model$tables$policy_type
```

```
##                    policy_type
## Y                Commercial   Personal
##    Cancel Conf     0.03901734 0.96098266
##    Cancel Req      0.20000000 0.80000000
##    Cancel/DNR      0.00000000 1.00000000
##    DB Synch        0.00000000 1.00000000
##    New Business    0.13559322 0.86440678
##    Non-Renewal     0.00000000 1.00000000
##    Policy Change   0.02842377 0.97157623
##    Re-Issue        0.00000000 1.00000000
##    Reinstate       0.02325581 0.97674419
##    Renew Quote     0.00000000 1.00000000
##    Renewal         0.08049536 0.91950464
```

```
##    Renewal Re-Quote 0.00000000 1.00000000
##    Rewrite           0.00000000 1.00000000
```

```r
# create one for binned premium
nb_model$tables$rating_state
```

```
##                   rating_state
## Y                          FL          ND          NV          OK
##    Cancel Conf     0.995664740 0.001445087 0.000000000 0.000000000
##    Cancel Req      1.000000000 0.000000000 0.000000000 0.000000000
##    Cancel/DNR      1.000000000 0.000000000 0.000000000 0.000000000
##    DB Synch        1.000000000 0.000000000 0.000000000 0.000000000
##    New Business    1.000000000 0.000000000 0.000000000 0.000000000
##    Non-Renewal     1.000000000 0.000000000 0.000000000 0.000000000
##    Policy Change   0.992248062 0.000000000 0.000000000 0.005167959
##    Re-Issue        1.000000000 0.000000000 0.000000000 0.000000000
##    Reinstate       1.000000000 0.000000000 0.000000000 0.000000000
##    Renew Quote     1.000000000 0.000000000 0.000000000 0.000000000
##    Renewal         0.996904025 0.000000000 0.000000000 0.003095975
##    Renewal Re-Quote 1.000000000 0.000000000 0.000000000 0.000000000
##    Rewrite         1.000000000 0.000000000 0.000000000 0.000000000
##                   rating_state
## Y                          OR          UT          WA          WY
##    Cancel Conf     0.001445087 0.001445087 0.000000000 0.000000000
##    Cancel Req      0.000000000 0.000000000 0.000000000 0.000000000
##    Cancel/DNR      0.000000000 0.000000000 0.000000000 0.000000000
##    DB Synch        0.000000000 0.000000000 0.000000000 0.000000000
##    New Business    0.000000000 0.000000000 0.000000000 0.000000000
##    Non-Renewal     0.000000000 0.000000000 0.000000000 0.000000000
##    Policy Change   0.000000000 0.000000000 0.000000000 0.002583979
##    Re-Issue        0.000000000 0.000000000 0.000000000 0.000000000
##    Reinstate       0.000000000 0.000000000 0.000000000 0.000000000
##    Renew Quote     0.000000000 0.000000000 0.000000000 0.000000000
##    Renewal         0.000000000 0.000000000 0.000000000 0.000000000
##    Renewal Re-Quote 0.000000000 0.000000000 0.000000000 0.000000000
##    Rewrite         0.000000000 0.000000000 0.000000000 0.000000000
```

```r
nb_model$tables$status
```

```
##                   status
## Y                      Active    Inactive
##    Cancel Conf     0.000000000 1.000000000
##    Cancel Req      0.000000000 1.000000000
##    Cancel/DNR      0.000000000 1.000000000
##    DB Synch        0.250000000 0.750000000
##    New Business    0.909604520 0.090395480
##    Non-Renewal     1.000000000 0.000000000
##    Policy Change   0.945736434 0.054263566
##    Re-Issue        1.000000000 0.000000000
##    Reinstate       0.837209302 0.162790698
##    Renew Quote     0.000000000 1.000000000
##    Renewal         0.996904025 0.003095975
##    Renewal Re-Quote 0.000000000 1.000000000
##    Rewrite         0.695652174 0.304347826
```

Some important points about the conditional probabilities:

1. The conditional probabilities by `assigned_agent` and transaction can help in workforce capacity planning. For example, if some agents are handling renewals more frequently, perhaps those agents need help.

2. `master_company` data can be used similarly to how `assigned_agent` is used in order to ensure companies with the most valuable business, or most frequently number of transactions, have the greatest amount of help.

3. For `policy_term` there is something unexpected: virtually all `New Business` transactions are 12 month, whereas renewals are 76%/24% 12 to 6 month. Why?

Make Predictions

As with the model, this step can take some real time with a large data set, so it's segregated from processing / output.

```
nb_predict <- predict(nb_model, test_ad)
```

Show the Predictions

This is similar to the conditional probability, but applies it to show the actual predicted values. The points about conditional probabilities all apply for the predictions, but this is where number of transactions are shown. As such, this is a more valuable workforce capacity planning metric.

However, the numbers shown here are based on the size of the test set. If you want to actually simulate workforce capacity, you'll need a sample that is similar to what you'll expect in a year (a model like this one can be used to make that prediction).

```
table(nb_predict, test_ad$account_type)
```

```
##
## nb_predict          Commercial Personal
##    Cancel Conf              7      639
##    Cancel Req               4        4
##    Cancel/DNR               0       17
##    DB Synch                 0        5
##    New Business            19        7
##    Non-Renewal              0        0
##    Policy Change            0        2
##    Re-Issue                 0        0
##    Reinstate                0        2
##    Renew Quote              0        0
##    Renewal                  0        1
##    Renewal Re-Quote         0        5
##    Rewrite                  0        1
```

```
table(nb_predict, test_ad$assigned_agent)
```

```
##
## nb_predict          Boehm, Sebastian Doyle, Walter Insurance, Nichersen
##    Cancel Conf                    84          268                     45
##    Cancel Req                      1            6                      0
##    Cancel/DNR                      2            0                     15
##    DB Synch                        0            1                      4
##    New Business                    0           17                      0
##    Non-Renewal                     0            0                      0
##    Policy Change                   2            0                      0
```

```
##     Re-Issue                           0               0                   0
##     Reinstate                          1               0                   0
##     Renew Quote                        0               0                   0
##     Renewal                            0               0                   0
##     Renewal Re-Quote                   2               0                   0
##     Rewrite                            0               0                   0
##
## nb_predict        Padberg, Tracy Rohan, Elwood Tremblay, Deena
##     Cancel Conf                  0               0                 249
##     Cancel Req                   0               0                   1
##     Cancel/DNR                   0               0                   0
##     DB Synch                     0               0                   0
##     New Business                 0               1                   8
##     Non-Renewal                  0               0                   0
##     Policy Change                0               0                   0
##     Re-Issue                     0               0                   0
##     Reinstate                    0               0                   1
##     Renew Quote                  0               0                   0
##     Renewal                      0               0                   1
##     Renewal Re-Quote             0               0                   3
##     Rewrite                      0               0                   1
```

```
table(nb_predict, test_ad$lob)
```

```
##
## nb_predict        Auto (Commercial) Auto (Personal) BOP Liability
##     Cancel Conf                   5             468             0
##     Cancel Req                    2               4             1
##     Cancel/DNR                    0              17             0
##     DB Synch                      0               4             0
##     New Business                  0               0             1
##     Non-Renewal                   0               0             0
##     Policy Change                 0               1             0
##     Re-Issue                      0               0             0
##     Reinstate                     0               1             0
##     Renew Quote                   0               0             0
##     Renewal                       0               0             0
##     Renewal Re-Quote              0               5             0
##     Rewrite                       0               1             0
##
## nb_predict        BOP Property Business Owners Policy Commercial Prpty
##     Cancel Conf              1                      1                 0
##     Cancel Req               0                      0                 0
##     Cancel/DNR               0                      0                 0
##     DB Synch                 0                      0                 0
##     New Business             0                      1                 1
##     Non-Renewal              0                      0                 0
##     Policy Change            0                      0                 0
##     Re-Issue                 0                      0                 0
##     Reinstate                0                      0                 0
##     Renew Quote              0                      0                 0
##     Renewal                  0                      0                 0
##     Renewal Re-Quote         0                      0                 0
##     Rewrite                  0                      0                 0
##
```

```
## nb_predict          Dwelling fire Flood Genl Liability Homeowners
##     Cancel Conf                  4     0             0        158
##     Cancel Req                   0     0             0          0
##     Cancel/DNR                   0     0             0          0
##     DB Synch                     0     0             0          0
##     New Business                 0     0            16          5
##     Non-Renewal                  0     0             0          0
##     Policy Change                0     0             0          1
##     Re-Issue                     0     0             0          0
##     Reinstate                    0     0             0          1
##     Renew Quote                  0     0             0          0
##     Renewal                      0     0             0          1
##     Renewal Re-Quote             0     0             0          0
##     Rewrite                      0     0             0          0
##
## nb_predict          Inland marine (comm) Inland Marine (pers)
##     Cancel Conf                        0                    1
##     Cancel Req                         0                    0
##     Cancel/DNR                         0                    0
##     DB Synch                           0                    0
##     New Business                       0                    0
##     Non-Renewal                        0                    0
##     Policy Change                      0                    0
##     Re-Issue                           0                    0
##     Reinstate                          0                    0
##     Renew Quote                        0                    0
##     Renewal                            0                    0
##     Renewal Re-Quote                   0                    0
##     Rewrite                            0                    0
##
## nb_predict          Personal Liability Professional Liab Renters Signs
##     Cancel Conf                      0                 0       1     1
##     Cancel Req                       0                 1       0     0
##     Cancel/DNR                       0                 0       0     0
##     DB Synch                         0                 0       1     0
##     New Business                     0                 1       0     0
##     Non-Renewal                      0                 0       0     0
##     Policy Change                    0                 0       0     0
##     Re-Issue                         0                 0       0     0
##     Reinstate                        0                 0       0     0
##     Renew Quote                      0                 0       0     0
##     Renewal                          0                 0       0     0
##     Renewal Re-Quote                 0                 0       0     0
##     Rewrite                          0                 0       0     0
##
## nb_predict          Umbrella - Comm Umbrella - Personal
##     Cancel Conf                   2                   3
##     Cancel Req                    0                   0
##     Cancel/DNR                    0                   0
##     DB Synch                      0                   0
##     New Business                  0                   1
##     Non-Renewal                   0                   0
##     Policy Change                 0                   0
##     Re-Issue                      0                   0
```

```
##    Reinstate                          0                    0
##    Renew Quote                        0                    0
##    Renewal                            0                    0
##    Renewal Re-Quote                   0                    0
##    Rewrite                            0                    0
##
## nb_predict          Watercraft (small boat) Workers comp
##    Cancel Conf                             1            0
##    Cancel Req                              0            0
##    Cancel/DNR                             0            0
##    DB Synch                               0            0
##    New Business                           0            0
##    Non-Renewal                            0            0
##    Policy Change                          0            0
##    Re-Issue                               0            0
##    Reinstate                              0            0
##    Renew Quote                            0            0
##    Renewal                                0            0
##    Renewal Re-Quote                       0            0
##    Rewrite                                0            0
```

```r
table(nb_predict, test_ad$master_company)
```

```
##
## nb_predict          Aimonetti Insurance Beaulah General Agency
##    Cancel Conf                       216                       0
##    Cancel Req                          6                       0
##    Cancel/DNR                          3                       0
##    DB Synch                            2                       0
##    New Business                        0                       2
##    Non-Renewal                         0                       0
##    Policy Change                       0                       0
##    Re-Issue                            0                       0
##    Reinstate                           0                       0
##    Renew Quote                         0                       0
##    Renewal                             0                       0
##    Renewal Re-Quote                    4                       0
##    Rewrite                             0                       0
##
## nb_predict          Beaulah Insurance Beyer Strategic Insurance
##    Cancel Conf                     56                          33
##    Cancel Req                       0                           0
##    Cancel/DNR                       0                           0
##    DB Synch                         0                           0
##    New Business                     1                           3
##    Non-Renewal                      0                           0
##    Policy Change                    0                           0
##    Re-Issue                         0                           0
##    Reinstate                        0                           0
##    Renew Quote                      0                           0
##    Renewal                          0                           0
##    Renewal Re-Quote                 0                           0
##    Rewrite                          0                           0
##
## nb_predict          Borer Group, LLC Brakus Fire & Casualty
```

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```
##    Cancel Conf                          0                        2
##    Cancel Req                           0                        0
##    Cancel/DNR                           0                        0
##    DB Synch                             0                        0
##    New Business                         0                        0
##    Non-Renewal                          0                        0
##    Policy Change                        0                        0
##    Re-Issue                             0                        0
##    Reinstate                            0                        0
##    Renew Quote                          0                        0
##    Renewal                              0                        0
##    Renewal Re-Quote                     0                        0
##    Rewrite                              0                        0
##
## nb_predict        Breitenberg Insurance DuBuque Insurance
##    Cancel Conf                        133                       57
##    Cancel Req                           0                        0
##    Cancel/DNR                          12                        0
##    DB Synch                             2                        0
##    New Business                         0                        2
##    Non-Renewal                          0                        0
##    Policy Change                        0                        1
##    Re-Issue                             0                        0
##    Reinstate                            0                        1
##    Renew Quote                          0                        0
##    Renewal                              1                        0
##    Renewal Re-Quote                     0                        1
##    Rewrite                              0                        0
##
## nb_predict        Friesen Insurance Helen Herman Group Hui Insurance
##    Cancel Conf                   24                    2             1
##    Cancel Req                     0                    1             0
##    Cancel/DNR                     0                    0             0
##    DB Synch                       0                    0             0
##    New Business                   0                    0             1
##    Non-Renewal                    0                    0             0
##    Policy Change                  0                    0             0
##    Re-Issue                       0                    0             0
##    Reinstate                      0                    0             0
##    Renew Quote                    0                    0             0
##    Renewal                        0                    0             0
##    Renewal Re-Quote               0                    0             0
##    Rewrite                        1                    0             0
##
## nb_predict        Kilback Excess & Surplus Roderick Insurance
##    Cancel Conf                          0                        4
##    Cancel Req                           1                        0
##    Cancel/DNR                           0                        0
##    DB Synch                             0                        0
##    New Business                         2                        0
##    Non-Renewal                          0                        0
##    Policy Change                        0                        1
##    Re-Issue                             0                        0
##    Reinstate                            0                        0
```

```
##    Renew Quote                                  0               0
##    Renewal                                      0               0
##    Renewal Re-Quote                             0               0
##    Rewrite                                      0               0
##
## nb_predict         Ryan Hyatt Insurance Schimel Mutual Insurance
##    Cancel Conf                        12                        2
##    Cancel Req                          0                        0
##    Cancel/DNR                          0                        0
##    DB Synch                            0                        0
##    New Business                        0                       14
##    Non-Renewal                         0                        0
##    Policy Change                       0                        0
##    Re-Issue                            0                        0
##    Reinstate                           0                        0
##    Renew Quote                         0                        0
##    Renewal                             0                        0
##    Renewal Re-Quote                    0                        0
##    Rewrite                             0                        0
##
## nb_predict         Schuppe Group Simonis Insurance Spinka West Insurance
##    Cancel Conf                 47               42                     11
##    Cancel Req                   0                0                      0
##    Cancel/DNR                   2                0                      0
##    DB Synch                     0                0                      0
##    New Business                 1                0                      0
##    Non-Renewal                  0                0                      0
##    Policy Change                0                0                      0
##    Re-Issue                     0                0                      0
##    Reinstate                    0                0                      0
##    Renew Quote                  0                0                      0
##    Renewal                      0                0                      0
##    Renewal Re-Quote             0                0                      0
##    Rewrite                      0                0                      0
##
## nb_predict         Streich Group Insurance Sultan Insurance
##    Cancel Conf                         4                0
##    Cancel Req                          0                0
##    Cancel/DNR                          0                0
##    DB Synch                            0                1
##    New Business                        0                0
##    Non-Renewal                         0                0
##    Policy Change                       0                0
##    Re-Issue                            0                0
##    Reinstate                           1                0
##    Renew Quote                         0                0
##    Renewal                             0                0
##    Renewal Re-Quote                    0                0
##    Rewrite                             0                0
```

```r
#table(nb_predict, test_ad$effective_date) # bin this
table(nb_predict, test_ad$policy_term)
```

```
##
## nb_predict          12 Months 6 Months 7 Months
```

```
##     Cancel Conf              361         285          0
##     Cancel Req                 4           4          0
##     Cancel/DNR                 1          16          0
##     DB Synch                   2           2          1
##     New Business              26           0          0
##     Non-Renewal                0           0          0
##     Policy Change              2           0          0
##     Re-Issue                   0           0          0
##     Reinstate                  2           0          0
##     Renew Quote                0           0          0
##     Renewal                    1           0          0
##     Renewal Re-Quote           1           4          0
##     Rewrite                    1           0          0
```

```r
table(nb_predict, test_ad$policy_type)
```

```
##
## nb_predict        Commercial Personal
##     Cancel Conf           10      636
##     Cancel Req             4        4
##     Cancel/DNR             0       17
##     DB Synch               0        5
##     New Business          20        6
##     Non-Renewal            0        0
##     Policy Change          0        2
##     Re-Issue               0        0
##     Reinstate              0        2
##     Renew Quote            0        0
##     Renewal                0        1
##     Renewal Re-Quote       0        5
##     Rewrite                0        1
```

```r
table(nb_predict, test_ad$rating_state)
```

```
##
## nb_predict         FL  ND  NV  OK  OR  UT  WA  WY
##     Cancel Conf   643   1   0   0   1   1   0   0
##     Cancel Req      8   0   0   0   0   0   0   0
##     Cancel/DNR     17   0   0   0   0   0   0   0
##     DB Synch        5   0   0   0   0   0   0   0
##     New Business   26   0   0   0   0   0   0   0
##     Non-Renewal     0   0   0   0   0   0   0   0
##     Policy Change   1   0   0   1   0   0   0   0
##     Re-Issue        0   0   0   0   0   0   0   0
##     Reinstate       2   0   0   0   0   0   0   0
##     Renew Quote     0   0   0   0   0   0   0   0
##     Renewal         1   0   0   0   0   0   0   0
##     Renewal Re-Quote 5   0   0   0   0   0   0   0
##     Rewrite         1   0   0   0   0   0   0   0
```

```r
table(nb_predict, test_ad$status)
```

```
##
## nb_predict        Active Inactive
##     Cancel Conf        0      646
##     Cancel Req         0        8
```

```
##    Cancel/DNR          0        17
##    DB Synch            0         5
##    New Business        1        25
##    Non-Renewal         0         0
##    Policy Change       1         1
##    Re-Issue            0         0
##    Reinstate           1         1
##    Renew Quote         0         0
##    Renewal             1         0
##    Renewal Re-Quote    0         5
##    Rewrite             1         0
```

Confusion Matrix

Build a simple confusion matrix and then plot it.

```
confusion_matrix <- table(nb_predict, test_ad$transaction_type)
```

Finally, Show Stats on the Confusion Matrix

```
## Confusion Matrix and Statistics
##
##
## nb_predict          Cancel Conf Cancel Req Cancel/DNR DB Synch New Business
##     Cancel Conf             615          3          1        0            7
##     Cancel Req                3          4          0        0            1
##     Cancel/DNR               11          0          4        0            0
##     DB Synch                  0          0          0        3            2
##     New Business             15          0          0        0            8
##     Non-Renewal               0          0          0        0            0
##     Policy Change             0          0          0        0            0
##     Re-Issue                  0          0          0        0            0
##     Reinstate                 0          0          0        0            0
##     Renew Quote               0          0          0        0            0
##     Renewal                   0          0          0        0            0
##     Renewal Re-Quote          3          0          0        0            0
##     Rewrite                   0          0          0        0            0
##
## nb_predict          Non-Renewal Policy Change Re-Issue Reinstate
##     Cancel Conf               0            14        0         5
##     Cancel Req                0             0        0         0
##     Cancel/DNR                0             2        0         0
##     DB Synch                  0             0        0         0
##     New Business              0             1        0         1
##     Non-Renewal               0             0        0         0
##     Policy Change             0             2        0         0
##     Re-Issue                  0             0        0         0
##     Reinstate                 0             1        0         1
##     Renew Quote               0             0        0         0
##     Renewal                   0             0        0         0
##     Renewal Re-Quote          0             0        0         1
##     Rewrite                   0             0        0         0
##
## nb_predict          Renew Quote Renewal Renewal Re-Quote Rewrite
##     Cancel Conf               1       0                0       0
```

```
##    Cancel Req                0       0            0       0
##    Cancel/DNR                0       0            0       0
##    DB Synch                  0       0            0       0
##    New Business              0       1            0       0
##    Non-Renewal               0       0            0       0
##    Policy Change             0       0            0       0
##    Re-Issue                  0       0            0       0
##    Reinstate                 0       0            0       0
##    Renew Quote               0       0            0       0
##    Renewal                   0       1            0       0
##    Renewal Re-Quote          0       0            1       0
##    Rewrite                   0       0            0       1
##
## Overall Statistics
##
##                Accuracy : 0.8976
##                  95% CI : (0.873, 0.9189)
##     No Information Rate : 0.9074
##     P-Value [Acc > NIR] : 0.8341
##
##                   Kappa : 0.4199
##
##   Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Cancel Conf Class: Cancel Req
## Sensitivity                     0.9505          0.571429
## Specificity                     0.5303          0.994334
## Pos Pred Value                  0.9520          0.500000
## Neg Pred Value                  0.5224          0.995745
## Prevalence                      0.9074          0.009818
## Detection Rate                  0.8626          0.005610
## Detection Prevalence            0.9060          0.011220
## Balanced Accuracy               0.7404          0.782881
##                      Class: Cancel/DNR Class: DB Synch Class: New Business
## Sensitivity                   0.800000        1.000000             0.44444
## Specificity                   0.981638        0.997183             0.97410
## Pos Pred Value                0.235294        0.600000             0.30769
## Neg Pred Value                0.998563        1.000000             0.98544
## Prevalence                    0.007013        0.004208             0.02525
## Detection Rate                0.005610        0.004208             0.01122
## Detection Prevalence          0.023843        0.007013             0.03647
## Balanced Accuracy             0.890819        0.998592             0.70927
##                      Class: Non-Renewal Class: Policy Change
## Sensitivity                          NA             0.100000
## Specificity                           1             1.000000
## Pos Pred Value                       NA             1.000000
## Neg Pred Value                       NA             0.974684
## Prevalence                            0             0.028050
## Detection Rate                        0             0.002805
## Detection Prevalence                  0             0.002805
## Balanced Accuracy                    NA             0.550000
##                      Class: Re-Issue Class: Reinstate Class: Renew Quote
```

```
## Sensitivity                            NA        0.125000              0.000000
## Specificity                             1        0.998582              1.000000
## Pos Pred Value                          NA        0.500000                   NaN
## Neg Pred Value                          NA        0.990155              0.998597
## Prevalence                              0        0.011220              0.001403
## Detection Rate                          0        0.001403              0.000000
## Detection Prevalence                    0        0.002805              0.000000
## Balanced Accuracy                       NA        0.561791              0.500000
##                    Class: Renewal Class: Renewal Re-Quote Class: Rewrite
## Sensitivity              0.500000                  1.000000       1.000000
## Specificity              1.000000                  0.994382       1.000000
## Pos Pred Value           1.000000                  0.200000       1.000000
## Neg Pred Value           0.998596                  1.000000       1.000000
## Prevalence               0.002805                  0.001403       0.001403
## Detection Rate           0.001403                  0.001403       0.001403
## Detection Prevalence     0.001403                  0.007013       0.001403
## Balanced Accuracy        0.750000                  0.997191       1.000000
```

Results Interpretation - MORE TO DO HERE I THINK

The predictive quality for agency data shows promise. Some very specific points about the results:

1. A 89.76% accuracy for `transaction_type` is very good.

2. There's a 95% chance that the accuracy is between 87.30% and 91.89% - also very good.

3. The accuracy is greater than the No Information Rate, which indicates significance. (Not always, but the upper CI is.)