

# 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 renewal will occur. That's the kind of probabilities being reported here.

```
nb_model$stables$assigned_agent
```

```
##
## Y assigned_agent
## Cancel Conf Boehm, Sebastian Doyle, Walter Insurance, Nichersen
## Cancel Req 0.109809663 0.442166911 0.051244510
## Cancel/DNR 0.000000000 0.571428571 0.000000000
## DB Synch 0.200000000 0.000000000 0.800000000
## New Business 0.000000000 0.250000000 0.500000000
## Non-Renewal 0.081871345 0.385964912 0.005847953
## Policy Change 0.000000000 0.000000000 0.000000000
## Re-Issue 0.114361702 0.359042553 0.005319149
## Reinstate 0.000000000 0.000000000 0.000000000
## Renew Quote 0.063829787 0.340425532 0.021276596
## Renewal 0.000000000 1.000000000 0.000000000
## Renewal Re-Quote 0.254385965 0.397660819 0.000000000
## Rewrite 1.000000000 0.000000000 0.000000000
## assigned_agent
## Y Padberg, Tracy Rohan, Elwood Tremblay, Deena
## Cancel Conf 0.010248902 0.013177160 0.373352855
## Cancel Req 0.000000000 0.142857143 0.285714286
## Cancel/DNR 0.000000000 0.000000000 0.000000000
## DB Synch 0.250000000 0.000000000 0.000000000
## New Business 0.157894737 0.070175439 0.298245614
## Non-Renewal 0.000000000 0.000000000 1.000000000
## Policy Change 0.127659574 0.077127660 0.316489362
## Re-Issue 0.000000000 0.000000000 1.000000000
## Reinstate 0.042553191 0.170212766 0.361702128
## Renew Quote 0.000000000 0.000000000 0.000000000
## Renewal 0.011695906 0.005847953 0.330409357
## Renewal Re-Quote 0.000000000 0.000000000 0.000000000
## Rewrite 0.000000000 0.000000000 0.500000000
```

```
nb_model$stables$lob
```

```
##
## Y lob
## Cancel Conf Auto (Commercial) Auto (Personal) BOP Liability
## Cancel Req 0.008784773 0.704245974 0.001464129
## Cancel/DNR 0.142857143 0.714285714 0.000000000
## DB Synch 0.000000000 1.000000000 0.000000000
```

##	New Business	0.017543860	0.192982456	0.000000000
##	Non-Renewal	0.000000000	1.000000000	0.000000000
##	Policy Change	0.013297872	0.694148936	0.000000000
##	Re-Issue	0.000000000	1.000000000	0.000000000
##	Reinstate	0.000000000	0.680851064	0.000000000
##	Renew Quote	0.000000000	1.000000000	0.000000000
##	Renewal	0.017543860	0.552631579	0.000000000
##	Renewal Re-Quote	0.000000000	1.000000000	0.000000000
##	Rewrite	0.000000000	0.750000000	0.000000000
##		lob		
##	Y	BOP Property Business Owners Policy Commercial Prpty		
##	Cancel Conf	0.001464129	0.002928258	0.001464129
##	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	0.017543860	0.005847953
##	Non-Renewal	0.000000000	0.000000000	0.000000000
##	Policy Change	0.000000000	0.002659574	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	0.002923977	0.005847953
##	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	0.013177160 0.000000000	0.016105417	0.240117130
##	Cancel Req	0.142857143 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	0.040935673 0.000000000	0.052631579	0.578947368
##	Non-Renewal	0.000000000 0.000000000	0.000000000	0.000000000
##	Policy Change	0.031914894 0.002659574	0.000000000	0.239361702
##	Re-Issue	0.000000000 0.000000000	0.000000000	0.000000000
##	Reinstate	0.042553191 0.000000000	0.021276596	0.234042553
##	Renew Quote	0.000000000 0.000000000	0.000000000	0.000000000
##	Renewal	0.011695906 0.000000000	0.032163743	0.347953216
##	Renewal Re-Quote	0.000000000 0.000000000	0.000000000	0.000000000
##	Rewrite	0.000000000 0.000000000	0.000000000	0.250000000
##		lob		
##	Y	Inland marine (comm) Inland Marine (pers)		
##	Cancel Conf	0.000000000	0.001464129	
##	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	0.005847953	0.005847953	
##	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         0.005847953          0.011695906 0.011695906
## 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          0.002928258          0.004392387
## 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          0.005847953          0.046783626
## Non-Renewal          0.000000000          0.000000000          0.000000000
## Policy Change        0.002659574          0.000000000          0.010638298
## Re-Issue             0.000000000          0.000000000          0.000000000
## Reinstate            0.000000000          0.000000000          0.021276596
## Renew Quote          0.000000000          0.000000000          0.000000000
## Renewal              0.000000000          0.000000000          0.014619883
## 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          0.001464129
## Cancel Req           0.000000000          0.000000000
## Cancel/DNR           0.000000000          0.000000000
## DB Synch             0.000000000          0.000000000
## New Business         0.005847953          0.005847953
## Non-Renewal          0.000000000          0.000000000
## Policy Change        0.002659574          0.000000000
## Re-Issue             0.000000000          0.000000000
## Reinstate            0.000000000          0.000000000
## Renew Quote          0.000000000          0.000000000
## Renewal              0.002923977          0.000000000
## Renewal Re-Quote     0.000000000          0.000000000
## Rewrite              0.000000000          0.000000000

```

nb\_model\$stables\$master\_company

```

##          master_company
## Y          Aimonetti Insurance Beaulah General Agency
## Cancel Conf          0.313323572          0.000000000
## Cancel Req           0.857142857          0.000000000
## Cancel/DNR           0.200000000          0.000000000
## DB Synch             0.750000000          0.000000000
## New Business         0.111111111          0.005847953

```

##	Non-Renewal	0.000000000	0.000000000
##	Policy Change	0.361702128	0.000000000
##	Re-Issue	1.000000000	0.000000000
##	Reinstate	0.340425532	0.000000000
##	Renew Quote	1.000000000	0.000000000
##	Renewal	0.307017544	0.002923977
##	Renewal Re-Quote	1.000000000	0.000000000
##	Rewrite	0.000000000	0.000000000
##	master_company		
## Y	Beulah Insurance Beyer Strategic Insurance		
##	Cancel Conf	0.084919473	0.054172767
##	Cancel Req	0.000000000	0.000000000
##	Cancel/DNR	0.000000000	0.000000000
##	DB Synch	0.000000000	0.000000000
##	New Business	0.017543860	0.093567251
##	Non-Renewal	0.000000000	0.000000000
##	Policy Change	0.050531915	0.047872340
##	Re-Issue	0.000000000	0.000000000
##	Reinstate	0.021276596	0.042553191
##	Renew Quote	0.000000000	0.000000000
##	Renewal	0.084795322	0.032163743
##	Renewal Re-Quote	0.000000000	0.000000000
##	Rewrite	0.125000000	0.000000000
##	master_company		
## Y	Borer Group, LLC Brakus Fire & Casualty		
##	Cancel Conf	0.004392387	0.002928258
##	Cancel Req	0.000000000	0.000000000
##	Cancel/DNR	0.000000000	0.000000000
##	DB Synch	0.000000000	0.000000000
##	New Business	0.076023392	0.000000000
##	Non-Renewal	0.000000000	0.000000000
##	Policy Change	0.045212766	0.000000000
##	Re-Issue	0.000000000	0.000000000
##	Reinstate	0.021276596	0.000000000
##	Renew Quote	0.000000000	0.000000000
##	Renewal	0.000000000	0.000000000
##	Renewal Re-Quote	0.000000000	0.000000000
##	Rewrite	0.125000000	0.000000000
##	master_company		
## Y	Breitenberg Insurance DuBuque Insurance		
##	Cancel Conf	0.175695461	0.105417277
##	Cancel Req	0.000000000	0.000000000
##	Cancel/DNR	0.600000000	0.000000000
##	DB Synch	0.250000000	0.000000000
##	New Business	0.099415205	0.169590643
##	Non-Renewal	1.000000000	0.000000000
##	Policy Change	0.066489362	0.138297872
##	Re-Issue	0.000000000	0.000000000
##	Reinstate	0.042553191	0.170212766
##	Renew Quote	0.000000000	0.000000000
##	Renewal	0.192982456	0.029239766
##	Renewal Re-Quote	0.000000000	0.000000000
##	Rewrite	0.000000000	0.125000000
##	master_company		

## Y	Friesen Insurance Helen Herman Group Hui Insurance		
##	Cancel Conf	0.040995608	0.004392387 0.019033675
##	Cancel Req	0.000000000	0.000000000 0.142857143
##	Cancel/DNR	0.000000000	0.000000000 0.000000000
##	DB Synch	0.000000000	0.000000000 0.000000000
##	New Business	0.011695906	0.000000000 0.204678363
##	Non-Renewal	0.000000000	0.000000000 0.000000000
##	Policy Change	0.053191489	0.002659574 0.066489362
##	Re-Issue	0.000000000	0.000000000 0.000000000
##	Reinstate	0.063829787	0.000000000 0.085106383
##	Renew Quote	0.000000000	0.000000000 0.000000000
##	Renewal	0.087719298	0.002923977 0.020467836
##	Renewal Re-Quote	0.000000000	0.000000000 0.000000000
##	Rewrite	0.333333333	0.000000000 0.083333333
##	master_company		
## Y	Kilback Excess & Surplus Roderick Insurance		
##	Cancel Conf	0.000000000	0.007320644
##	Cancel Req	0.000000000	0.000000000
##	Cancel/DNR	0.000000000	0.000000000
##	DB Synch	0.000000000	0.000000000
##	New Business	0.029239766	0.046783626
##	Non-Renewal	0.000000000	0.000000000
##	Policy Change	0.000000000	0.063829787
##	Re-Issue	0.000000000	0.000000000
##	Reinstate	0.000000000	0.042553191
##	Renew Quote	0.000000000	0.000000000
##	Renewal	0.000000000	0.093567251
##	Renewal Re-Quote	0.000000000	0.000000000
##	Rewrite	0.000000000	0.000000000
##	master_company		
## Y	Ryan Hyatt Insurance Schimel Mutual Insurance		
##	Cancel Conf	0.008784773	0.021961933
##	Cancel Req	0.000000000	0.000000000
##	Cancel/DNR	0.000000000	0.000000000
##	DB Synch	0.000000000	0.000000000
##	New Business	0.000000000	0.040935673
##	Non-Renewal	0.000000000	0.000000000
##	Policy Change	0.002659574	0.000000000
##	Re-Issue	0.000000000	0.000000000
##	Reinstate	0.021276596	0.021276596
##	Renew Quote	0.000000000	0.000000000
##	Renewal	0.000000000	0.046783626
##	Renewal Re-Quote	0.000000000	0.000000000
##	Rewrite	0.000000000	0.000000000
##	master_company		
## Y	Schuppe Group Simonis Insurance Spinka West Insurance		
##	Cancel Conf	0.061493411	0.048316252 0.038067350
##	Cancel Req	0.000000000	0.000000000 0.000000000
##	Cancel/DNR	0.200000000	0.000000000 0.000000000
##	DB Synch	0.000000000	0.000000000 0.000000000
##	New Business	0.052631579	0.023391813 0.005847953
##	Non-Renewal	0.000000000	0.000000000 0.000000000
##	Policy Change	0.077127660	0.007978723 0.007978723
##	Re-Issue	0.000000000	0.000000000 0.000000000

##	Reinstate	0.021276596	0.021276596	0.021276596
##	Renew Quote	0.000000000	0.000000000	0.000000000
##	Renewal	0.046783626	0.014619883	0.011695906
##	Renewal Re-Quote	0.000000000	0.000000000	0.000000000
##	Rewrite	0.208333333	0.000000000	0.000000000
##	master_company			
## Y		Streich Group	Insurance	Sultan Insurance
##	Cancel Conf		0.008784773	0.000000000
##	Cancel Req		0.000000000	0.000000000
##	Cancel/DNR		0.000000000	0.000000000
##	DB Synch		0.000000000	0.000000000
##	New Business		0.011695906	0.000000000
##	Non-Renewal		0.000000000	0.000000000
##	Policy Change		0.007978723	0.000000000
##	Re-Issue		0.000000000	0.000000000
##	Reinstate		0.063829787	0.000000000
##	Renew Quote		0.000000000	0.000000000
##	Renewal		0.026315789	0.000000000
##	Renewal Re-Quote		0.000000000	0.000000000
##	Rewrite		0.000000000	0.000000000

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

##		policy_term		
## Y		12 Months	6 Months	7 Months
##	Cancel Conf	0.55490483	0.44509517	0.00000000
##	Cancel Req	0.42857143	0.57142857	0.00000000
##	Cancel/DNR	0.20000000	0.80000000	0.00000000
##	DB Synch	0.50000000	0.50000000	0.00000000
##	New Business	0.98830409	0.01169591	0.00000000
##	Non-Renewal	1.00000000	0.00000000	0.00000000
##	Policy Change	0.84308511	0.15691489	0.00000000
##	Re-Issue	1.00000000	0.00000000	0.00000000
##	Reinstate	0.74468085	0.25531915	0.00000000
##	Renew Quote	0.00000000	1.00000000	0.00000000
##	Renewal	0.76608187	0.23391813	0.00000000
##	Renewal Re-Quote	1.00000000	0.00000000	0.00000000
##	Rewrite	0.95833333	0.04166667	0.00000000

```
nb_model$stables$policy_type
```

##		policy_type	
## Y		Commercial	Personal
##	Cancel Conf	0.03953148	0.96046852
##	Cancel Req	0.28571429	0.71428571
##	Cancel/DNR	0.00000000	1.00000000
##	DB Synch	0.00000000	1.00000000
##	New Business	0.11695906	0.88304094
##	Non-Renewal	0.00000000	1.00000000
##	Policy Change	0.03457447	0.96542553
##	Re-Issue	0.00000000	1.00000000
##	Reinstate	0.04255319	0.95744681
##	Renew Quote	0.00000000	1.00000000
##	Renewal	0.06432749	0.93567251

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

```
# create one for binned premium
nb_model$stables$rating_state
```

```
##
## Y          rating_state
##          FL          ND          NV          OK
## Cancel Conf 0.997071742 0.001464129 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 0.994152047 0.000000000 0.000000000 0.000000000
## Non-Renewal 1.000000000 0.000000000 0.000000000 0.000000000
## Policy Change 0.992021277 0.000000000 0.000000000 0.005319149
## 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      0.997076023 0.000000000 0.000000000 0.002923977
## 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 0.000000000 0.001464129 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 0.005847953 0.000000000
## Non-Renewal 0.000000000 0.000000000 0.000000000 0.000000000
## Policy Change 0.000000000 0.000000000 0.000000000 0.002659574
## 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
```

```
nb_model$stables$status
```

```
##
## Y          status
##          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 0.912280702 0.087719298
## Non-Renewal 1.000000000 0.000000000
## Policy Change 0.944148936 0.055851064
## Re-Issue     1.000000000 0.000000000
## Reinstate    0.851063830 0.148936170
## Renew Quote  0.000000000 1.000000000
## Renewal      0.997076023 0.002923977
## Renewal Re-Quote 0.000000000 1.000000000
## Rewrite      0.708333333 0.291666667
```

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      8          638
## Cancel Req       4           4
## Cancel/DNR       0          22
## DB Synch         0           6
## New Business     18           8
## Non-Renewal      0           0
## Policy Change    0           1
## Re-Issue         0           0
## Reinstate        0           2
## Renew Quote      0           0
## Renewal          0           1
## Renewal Re-Quote 0           0
## Rewrite          0           1
```

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

```
##
## nb_predict      Boehm, Sebastian Doyle, Walter Insurance, Nichersen
## Cancel Conf      86          269          39
## Cancel Req       1           6           0
## Cancel/DNR       1           0          21
## DB Synch         1           1           4
## New Business     2          16           0
## Non-Renewal      0           0           0
## Policy Change    1           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 Padberg, Tracy Rohan, Elwood Tremblay, Deena
## Cancel Conf 0 0 252
## Cancel Req 0 0 1
## Cancel/DNR 0 0 0
## DB Synch 0 0 0
## New Business 0 1 7
## Non-Renewal 0 0 0
## Policy Change 0 0 0
## Re-Issue 0 0 0
## Reinstate 0 0 2
## Renew Quote 0 0 0
## Renewal 0 0 1
## Renewal Re-Quote 0 0 0
## Rewrite 0 0 1
table(nb_predict, test_ad$lob)

##
## nb_predict Auto (Commercial) Auto (Personal) BOP Liability
## Cancel Conf 5 466 1
## Cancel Req 2 4 1
## Cancel/DNR 0 22 0
## DB Synch 0 5 0
## New Business 0 0 0
## Non-Renewal 0 0 0
## Policy Change 0 1 0
## Re-Issue 0 0 0
## Reinstate 0 2 0
## Renew Quote 0 0 0
## Renewal 0 0 0
## Renewal Re-Quote 0 0 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 3 0 0 160
## Cancel Req 0 0 0 0

```

##	Cancel/DNR	0	0	0	0
##	DB Synch	0	0	0	0
##	New Business	1	0	16	5
##	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	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	0	1
##	Cancel Req	0	1	0	0
##	Cancel/DNR	0	0	0	0
##	DB Synch	0	0	1	0
##	New Business	0	1	1	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	4
##	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 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
```

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

```
##
## nb_predict Aimonetti Insurance Beulah General Agency
## Cancel Conf 217 0
## Cancel Req 6 0
## Cancel/DNR 5 0
## DB Synch 3 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 0 0
## Rewrite 0 0
##
## nb_predict Beulah Insurance Beyer Strategic Insurance
## Cancel Conf 57 33
## Cancel Req 0 0
## Cancel/DNR 0 0
## DB Synch 0 0
## New Business 0 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
## 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	129	58	
##	Cancel Req	0	0	
##	Cancel/DNR	16	0	
##	DB Synch	2	0	
##	New Business	0	2	
##	Non-Renewal	0	0	
##	Policy Change	0	0	
##	Re-Issue	0	0	
##	Reinstate	0	2	
##	Renew Quote	0	0	
##	Renewal	1	0	
##	Renewal Re-Quote	0	0	
##	Rewrite	0	0	
##				
##	nb_predict	Friesen Insurance	Helen Herman Group	Hui Insurance
##	Cancel Conf	24	2	0
##	Cancel Req	0	1	0
##	Cancel/DNR	0	0	0
##	DB Synch	0	0	0
##	New Business	0	0	2
##	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                48                               42                               11
## Cancel Req                 0                                0                                0
## Cancel/DNR                 1                                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                5                                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                  0                                0
## Renew Quote                 0                                0
## Renewal                    0                                0
## Renewal Re-Quote           0                                0
## Rewrite                    0                                0

```

```

#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        363      283      0
## Cancel Req         4        4      0
## Cancel/DNR         1       21      0

```

```
## DB Synch      2      3      1
## New Business  26      0      0
## Non-Renewal   0      0      0
## Policy Change 1      0      0
## Re-Issue      0      0      0
## Reinstate     2      0      0
## Renew Quote   0      0      0
## Renewal       1      0      0
## Renewal Re-Quote 0      0      0
## Rewrite       1      0      0
```

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

```
##
## nb_predict      Commercial Personal
## Cancel Conf      11      635
## Cancel Req        4        4
## Cancel/DNR        0       22
## DB Synch          0        6
## New Business      19        7
## Non-Renewal        0        0
## Policy Change      0        1
## Re-Issue           0        0
## Reinstate          0        2
## Renew Quote        0        0
## Renewal            0        1
## Renewal Re-Quote    0        0
## Rewrite            0        1
```

```
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      22   0   0   0   0   0   0   0
## DB Synch         6   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    0   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 0   0   0   0   0   0   0   0
## Rewrite          1   0   0   0   0   0   0   0
```

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

```
##
## nb_predict      Active Inactive
## Cancel Conf      0      646
## Cancel Req        0        8
## Cancel/DNR        0       22
## DB Synch          0        6
## New Business      2       24
```

```
## Non-Renewal      0      0
## Policy Change    0      1
## Re-Issue         0      0
## Reinstate        1      1
## Renew Quote      0      0
## Renewal          1      0
## Renewal Re-Quote 0      0
## 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      613      3      0      0      0      8
## Cancel Req       3      4      0      0      0      1
## Cancel/DNR       15      0      5      0      0      0
## DB Synch         1      0      0      3      0      2
## New Business     15      0      0      0      0      7
## Non-Renewal      0      0      0      0      0      0
## Policy Change    0      0      0      0      0      0
## Re-Issue         0      0      0      0      0      0
## Reinstate        0      0      0      0      0      0
## Renew Quote      0      0      0      0      0      0
## Renewal          0      0      0      0      0      0
## Renewal Re-Quote 0      0      0      0      0      0
## Rewrite          0      0      0      0      0      0
```

```
##
```

```
## nb_predict      Non-Renewal Policy Change Re-Issue Reinstate
## Cancel Conf      0      14      0      6
## Cancel Req       0      0      0      0
## Cancel/DNR       0      2      0      0
## DB Synch         0      0      0      0
## New Business     0      2      0      1
## Non-Renewal      0      0      0      0
## Policy Change    0      1      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      0
## Rewrite          0      0      0      0
```

```
##
```

```
## nb_predict      Renew Quote Renewal Renewal Re-Quote Rewrite
## Cancel Conf      1      0      1      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          0      0
## Rewrite                0      0          0      1
##
## Overall Statistics
##
##           Accuracy : 0.892
##           95% CI : (0.8669, 0.9138)
##           No Information Rate : 0.9074
##           P-Value [Acc > NIR] : 0.9288
##
##           Kappa : 0.3881
##
## McNemar's Test P-Value : NA
##
## Statistics by Class:
##
##           Class: Cancel Conf Class: Cancel Req
## Sensitivity           0.9474          0.571429
## Specificity           0.5000          0.994334
## Pos Pred Value        0.9489          0.500000
## Neg Pred Value        0.4925          0.995745
## Prevalence            0.9074          0.009818
## Detection Rate        0.8597          0.005610
## Detection Prevalence  0.9060          0.011220
## Balanced Accuracy     0.7237          0.782881
##
##           Class: Cancel/DNR Class: DB Synch Class: New Business
## Sensitivity           1.000000          1.000000          0.388889
## Specificity           0.975989          0.995775          0.972662
## Pos Pred Value        0.227273          0.500000          0.269231
## Neg Pred Value        1.000000          1.000000          0.983988
## Prevalence            0.007013          0.004208          0.025245
## Detection Rate        0.007013          0.004208          0.009818
## Detection Prevalence  0.030856          0.008415          0.036466
## Balanced Accuracy     0.987994          0.997887          0.680775
##
##           Class: Non-Renewal Class: Policy Change
## Sensitivity           NA              0.050000
## Specificity           1              1.000000
## Pos Pred Value        NA              1.000000
## Neg Pred Value        NA              0.973315
## Prevalence            0              0.028050
## Detection Rate        0              0.001403
## Detection Prevalence  0              0.001403
## Balanced Accuracy     NA              0.525000
##
##           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		0.000000 1.000000
## Specificity	1.000000		1.000000 1.000000
## Pos Pred Value	1.000000		NaN 1.000000
## Neg Pred Value	0.998596		0.998597 1.000000
## Prevalence	0.002805		0.001403 0.001403
## Detection Rate	0.001403		0.000000 0.001403
## Detection Prevalence	0.001403		0.000000 0.001403
## Balanced Accuracy	0.750000		0.500000 1.000000

The predictive quality for agency data shows promise. Some very specific points about the results: 1. A 0.8920056 accuracy for **transaction\_type** is very good. 2. There's a 95% chance that the accuracy is between 88% and 93% - also very good. 3. The accuracy is greater than the No Information Rate, which indicates significance.