STA380 - INTRO TO MACHINE LEARNING

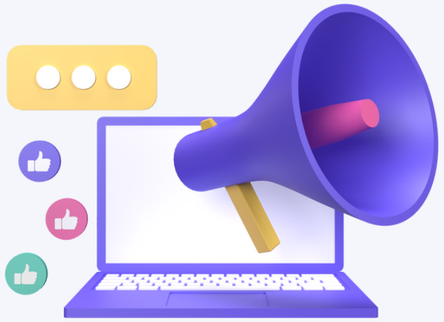
PREDICTING START-UP SUCCESS

By: Apurva Audi, Amanda Nguyen, James Anderson, Sameer Ahmed, and Shubhada Kapre

PROBLEM STATEMENT

We ultimately attempt to predict whether or not a company in a top US start up city will be successful.

AGENDA



Introduction

Background about the dataset

Framework

What methods we used to analyze data

Analysis

How we approached this problem

Results

What we found from our analysis

INTRODUCTION

What we are predicting:

Prediction of start-up success based on:

- Total funding
- Number of funding rounds
- Size of funding : seed & venture
- Market: Technology & Non-technology
- Time between first and last funding round

Inherent Problems:

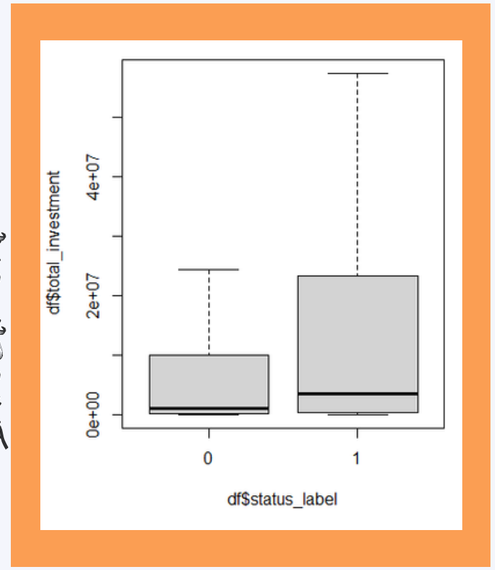
- Defining success vs failure is incredibly nuanced.
- Data given classified companies as "operating", "acquired", or "closed".
- 5% of data set was "closed", a strong bias given that in reality, 90% of start ups fail

More PROBLEMS

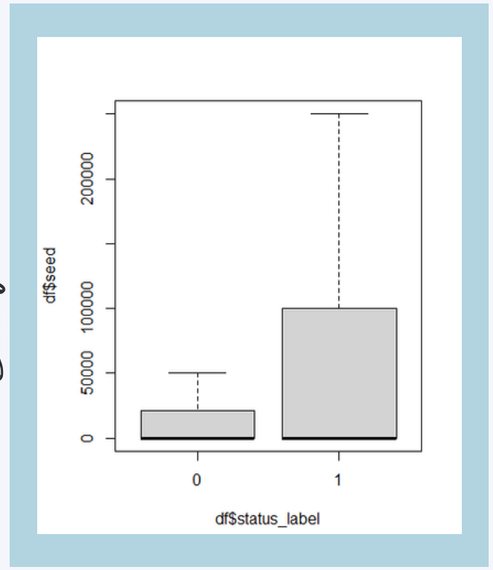
- Unrealistic closed company data set
- Operating & Acquired are subjective indicators of success
- Different companies have different funding needs
- Models do not predict seed-stage companies
- Region/Industry heavily influence financial data

EXPLORATORY DATA ANALYSIS

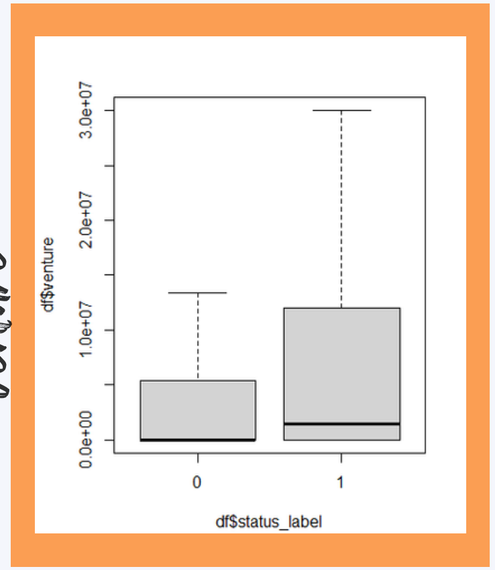
Investment



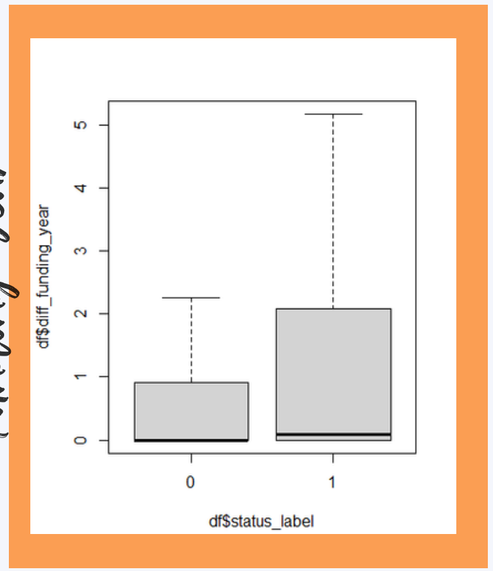
Seed



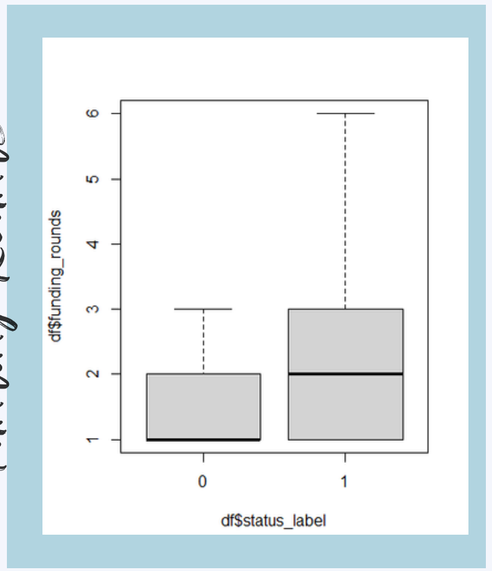
Venture



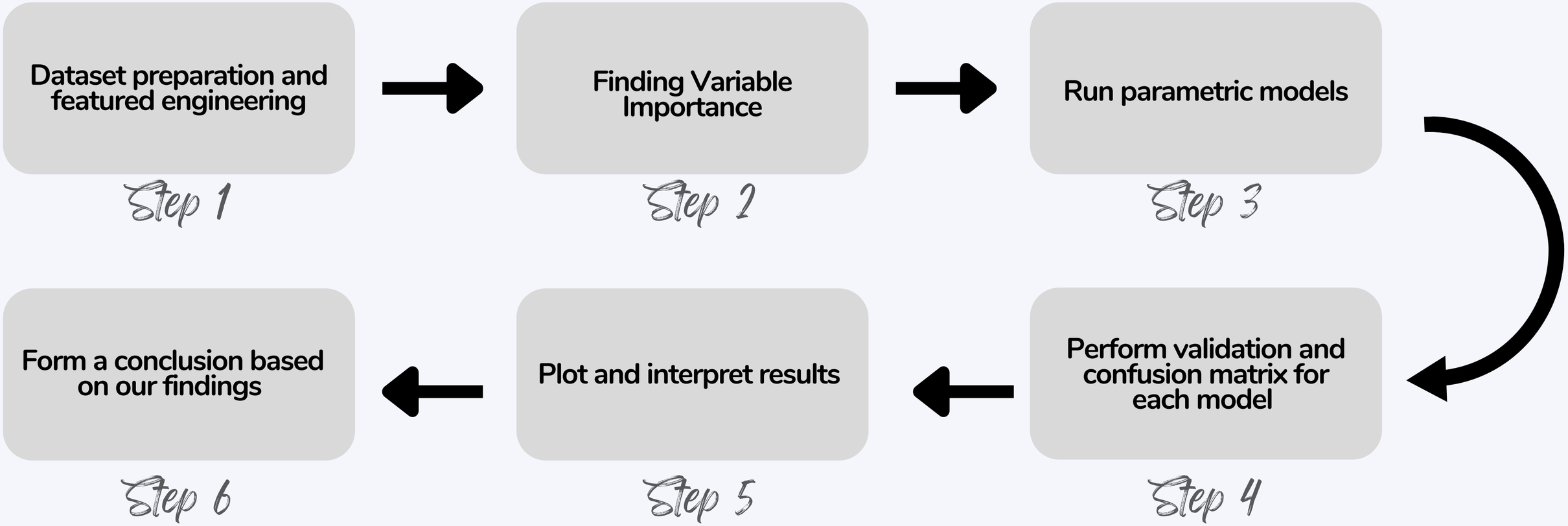
Funding Year



Funding Rounds



FRAMEWORK


Dataset preparation and featured engineering
Step 1
Finding Variable Importance
Step 2
Run parametric models
Step 3
Perform validation and confusion matrix for each model
Step 4
Plot and interpret results
Step 5
Form a conclusion based on our findings
Step 6

FRAMEWORK

INPUT

- Dataset from kaggle with historical data from start ups.
- Funding rounds, seed, venture, convertible debt, total investment, etc.

PROCESS

Analysis Used:

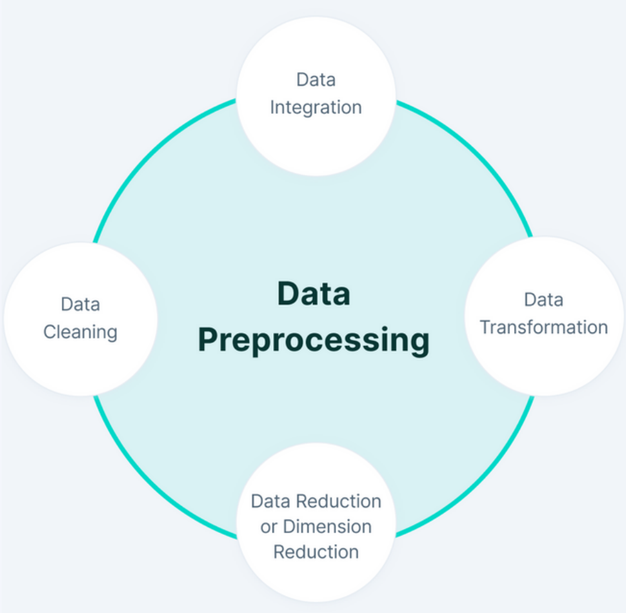
- Parametric Models
  - Lasso & Ridge
  - Logistic Regression
  - Decision Tree
  - Bagging
  - Boosting
  - Random Forest Classifier

OUTPUT

- A group of models that predict success of a startup.
- Using Confusion Matrix to compute prediction accuracy, recall, F1 score and AUC.

DATA PRE-PROCESSING

- Actual records in the dataset - **44k**
- Covers startups across **120+** countries and **700+** markets
- Focused analysis on USA market in top **8** startup areas



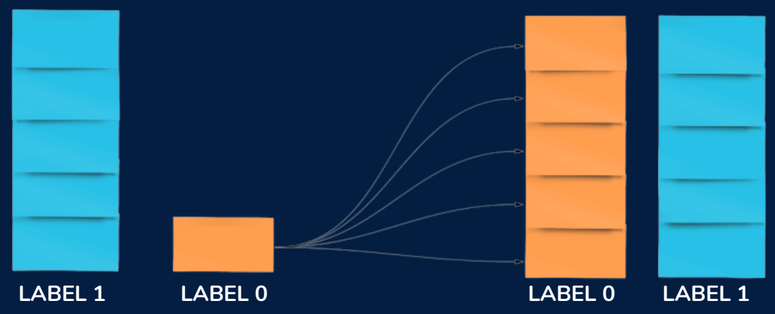
Removing records with missing values.

Converting strings to numerical values for funding

Classifying Market : Technology & Non-Technology

Handling Categorical Data by creating Categorical Bins and using numerical encoding

IMBALANCE CLASSES IN DATASET



OVERSAMPLING

Dataset before Over Sampling

```
> table(df_inv$status_label)

    0     1
  716 12095
```

Using Over Sampling via the package **ROSE** - Random Over-Sampling Method to replicate the minority class

Dataset after Over Sampling

```
> data_balanced_over <- ovun.sample(status_label ~ ., data = df_inv, method = "over",N = 24190)$data
> table(data_balanced_over$status_label)

    0     1
12095 12095
```

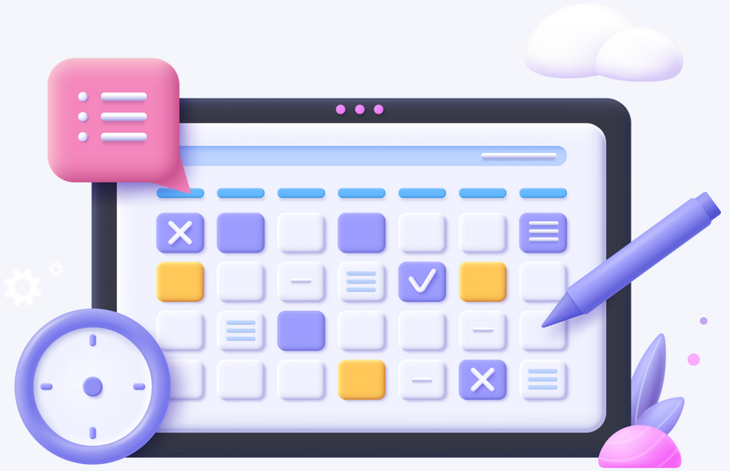
*Status Label:
0 - Failure (close)
1 - Success (acquired, operating)

ANALYSIS MODELS

VARIABLE SELECTION

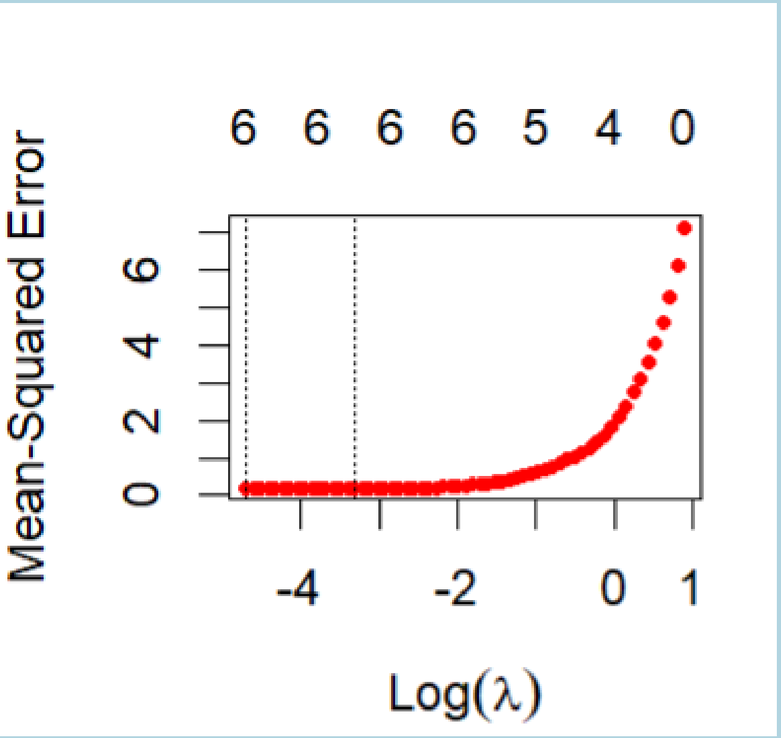
Lasso Regression

For removing non-important predictors from the model



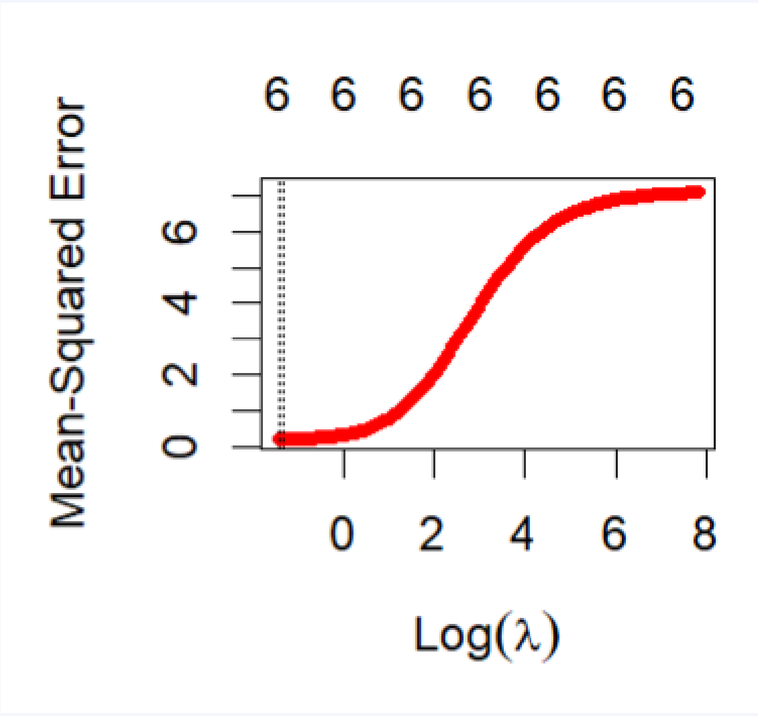
Ridge Regression

Assuring penalty factor and coefficients are appropriate for accurate prediction



LAMBDA SELECTION

determining the right amount of shrinkage



Lasso Regression

(Intercept)	market_type
1.0117284	0.9755215
total_investment_cde	diff_funding_year_cde
1.0550909	1.0088068
funding_rounds_cde	seed_cde
0.9741143	0.9537323
venture_cde	
1.0134712	

Ridge Regression

(Intercept)	market_type
1.1613541	0.9312577
total_investment_cde	diff_funding_year_cde
0.9604958	1.0314023
funding_rounds_cde	seed_cde
0.9928223	0.9005296
venture_cde	
1.0350786	

VARIABLE COEFFICIENTS

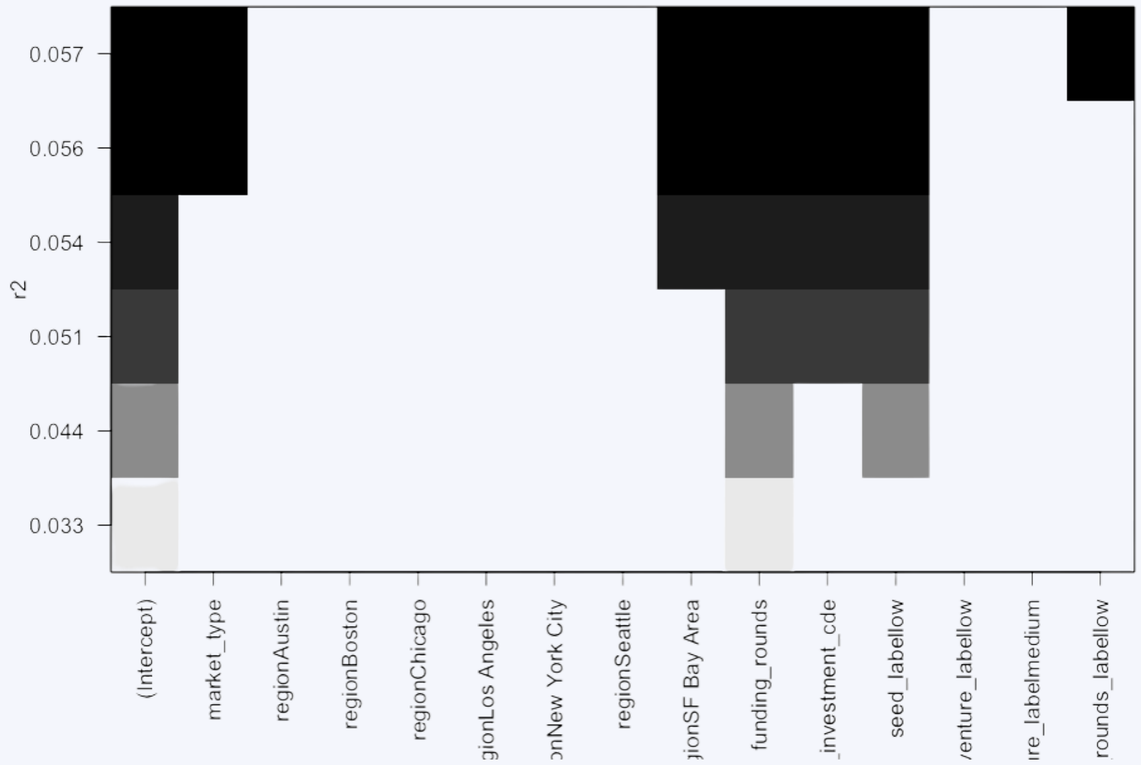
Logistic Regression

FEATURE SELECTION

2 MAIN FACTORS:

Lasso and Ridge feature selection

Regsubset backward selection



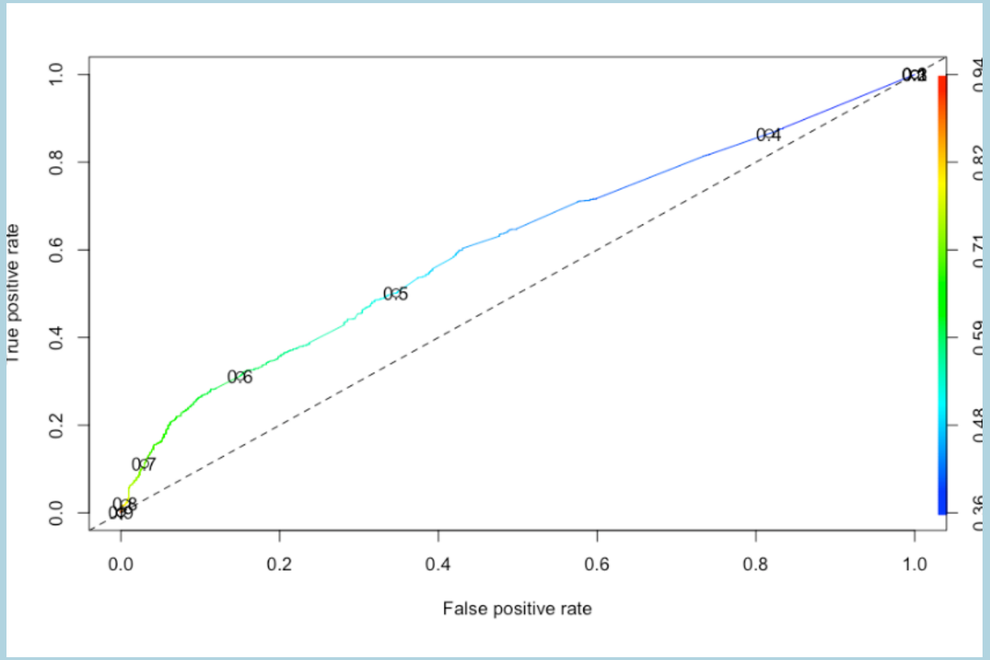
OUR BEST LOG MODEL

- TOTAL INVESTMENT
- FUNDING ROUNDS
- SEED
- VENTURE
- MARKET TYPE
- FUNDING YEAR

```
Call:
glm(formula = status ~ diff_funding_year + market_type + funding_rounds +
    seed_label + total_investment_cde, family = "binomial", data = df_inv_Train)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.0029  -1.0775   0.5758   1.1569   1.4283

Coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)          0.12912    0.05490   2.352   0.0187 *
diff_funding_year    0.08910    0.01654   5.386 7.19e-08 ***
market_type         -0.22241    0.03301  -6.738 1.61e-11 ***
funding_rounds       0.11410    0.02025   5.636 1.74e-08 ***
seed_labellow       -0.59355    0.04389 -13.522  < 2e-16 ***
total_investment_cde  0.16658    0.01756   9.488  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 23472  on 16931  degrees of freedom
Residual deviance: 22503  on 16926  degrees of freedom
AIC: 22515

Number of Fisher Scoring iterations: 4
```

*DETERMINED THROUGH COMPARASION OF AIC & VALIDATION ON TEST SET

Roc Chart



AUC: .6108

Confusion Matrix

```
               Accuracy : 0.5788
                 95% CI : (0.5673, 0.5901)
    No Information Rate : 0.5775
    P-Value [Acc > NIR] : 0.4202

                  Kappa : 0.1554

 Mcnemar's Test P-Value : <2e-16

            Sensitivity : 0.5753
            Specificity : 0.5835
         Pos Pred Value : 0.6537
         Neg Pred Value : 0.5013
              Precision : 0.6537
                 Recall : 0.5753
                     F1 : 0.6120
             Prevalence : 0.5775
         Detection Rate : 0.3322
   Detection Prevalence : 0.5082
      Balanced Accuracy : 0.5794

       'Positive' Class : closed
```

ANALYSIS

TREES

BAGGING

BOOSTING

RANDOM FORESTS

USING A SINGLE TREE

Predictors Used:

01 **TOTAL INVESTMENT**

02 **SEED CAPITAL**

03 **VENTURE CAPITAL**

04 **FUNDING YEARS**

05 **FUNDING ROUNDS**

06 **MARKET TYPE**

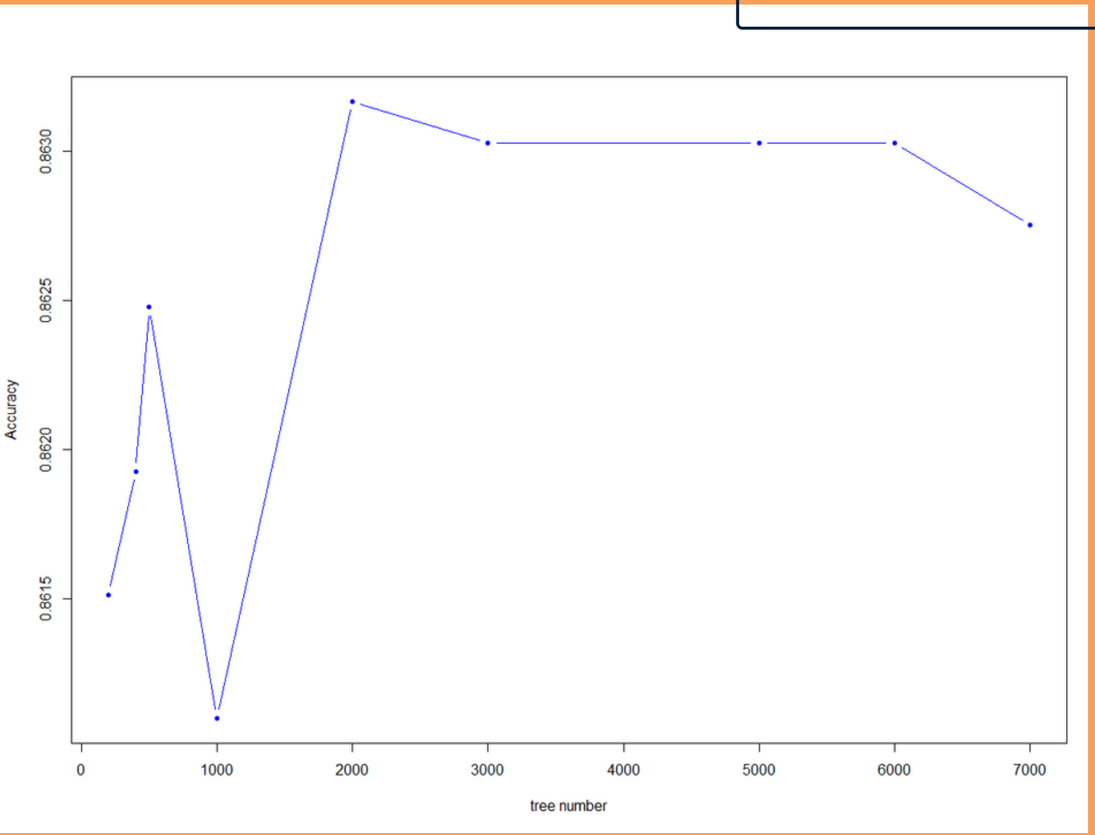
Number of terminal nodes : 72

Misclassification error rate: 0.3314

Accuracy : 66.93%

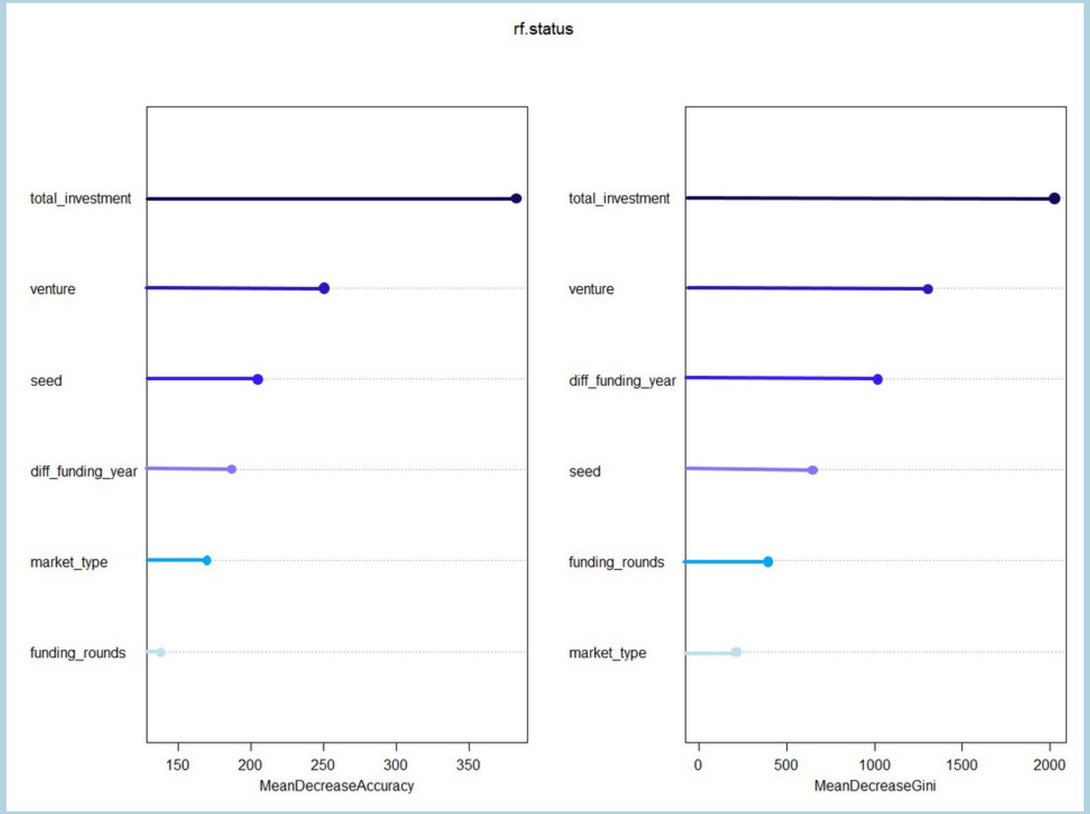
```
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 2879 1610
         1  790 1978

               Accuracy : 0.6693
                 95% CI : (0.6583, 0.6801)
    No Information Rate : 0.5056
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.3368

 Mcnemar's Test P-Value : < 2.2e-16

            Sensitivity : 0.7847
            Specificity : 0.5513
         Pos Pred Value : 0.6413
         Neg Pred Value : 0.7146
              Precision : 0.6413
                 Recall : 0.7847
                     F1 : 0.7058
             Prevalence : 0.5056
         Detection Rate : 0.3967
   Detection Prevalence : 0.6186
      Balanced Accuracy : 0.6680

       'Positive' Class : 0
```

BAGGING




```
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 3577  900
         1   92 2688

               Accuracy : 0.8633
                 95% CI : (0.8552, 0.8711)
    No Information Rate : 0.5056
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.7259

 Mcnemar's Test P-Value : < 2.2e-16

            Sensitivity : 0.9749
            Specificity : 0.7492
         Pos Pred Value : 0.7990
         Neg Pred Value : 0.9669
              Precision : 0.7990
                 Recall : 0.9749
                     F1 : 0.8782
             Prevalence : 0.5056
         Detection Rate : 0.4929
   Detection Prevalence : 0.6169
      Balanced Accuracy : 0.8620

       'Positive' Class : 0
```

RANDOM FOREST




```
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 3578  925
         1   91 2663

               Accuracy : 0.86
                 95% CI : (0.8518, 0.8679)
    No Information Rate : 0.5056
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.7192

 Mcnemar's Test P-Value : < 2.2e-16

            Sensitivity : 0.9752
            Specificity : 0.7422
         Pos Pred Value : 0.7946
         Neg Pred Value : 0.9670
              Precision : 0.7946
                 Recall : 0.9752
                     F1 : 0.8757
             Prevalence : 0.5056
         Detection Rate : 0.4930
   Detection Prevalence : 0.6205
      Balanced Accuracy : 0.8587

       'Positive' Class : 0
```

01 Subset of predictors

Resulted in the reveal of 2 most important variables

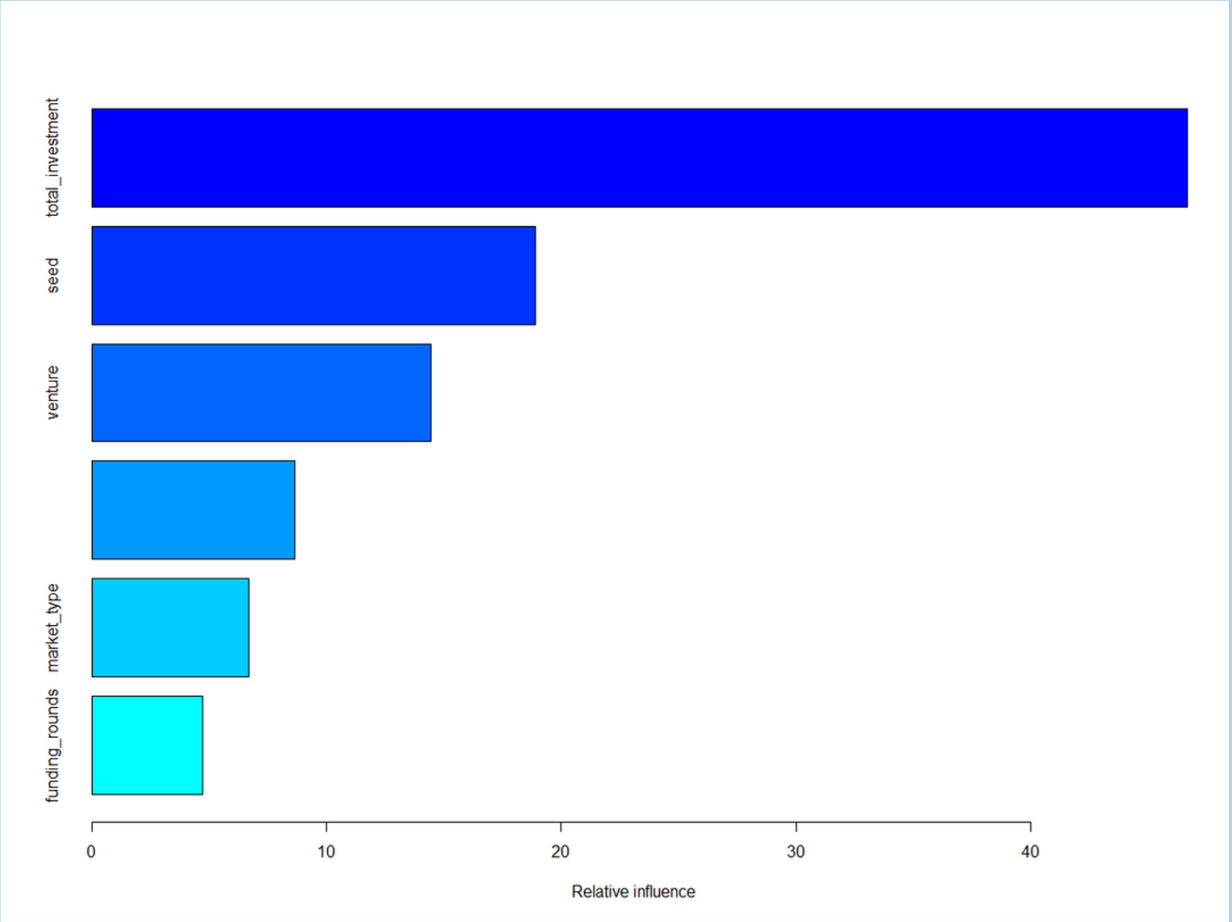
02 Confusion Matrix

This confirms our results from previous models

BOOSTING

Different combinations of B, d, λ

Tdepth (d)	Ntree (B)	Lambda	Accuracy
3	100	0.2	68.97
3	1000	0.2	81.4
3	3000	0.2	84.26
3	4000	0.2	84.5
3	5000	0.2	83.04
4	1000	0.2	82.39
4	1000	0.01	67.23
4	4000	0.01	75.53
10	1000	0.01	75.03
10	3000	0.01	71.62



RESULTS

TOTAL INVESTMENT

VENTURE CAPITAL

FUNDING YEARS

THANK YOU!

Any questions?