Project: Creditworthiness

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Step 1: Business and Data Understanding

Provide an explanation of the key decisions that need to be made. (250 word limit)

Identifying the creditworthiness of customers of a small bank. New customers will apply for loan. It is the job of the loan officer to identify the creditworthiness of these applicants. Using classification models, we can find the creditworthy customers and report to manager.
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Key Decisions:

Answer these questions

- What decisions needs to be made?
  Is the loan applicant creditworthy or not.

- What data is needed to inform those decisions?
  Data on all the past loan applicants and details of all new loan applicants.

- What kind of model (Continuous, Binary, Non-Binary, Time-Series) do we need to use to help make these decisions?
  We have to identify the creditworthiness. So, is the customer creditworthy or Not, which is binary.

Step 2: Building the Training Set

Build your training set given the data provided to you. The data has been cleaned up for you already so you shouldn't ***need to convert any data fields to the appropriate data types.***

Here are some guidelines to help guide your data cleanup:

- For numerical data fields, are there any fields that highly-correlate with each other? The correlation should be at least .70 to be considered "high".
- Are there any missing data for each of the data fields? Fields with a lot of missing data should be removed

- Are there only a few values in a subset of your data field? Does the data field look very uniform (there is only one value for the entire field?). This is called “low variability” and you should remove fields that have low variability. Refer to the "Tips" section to find examples of data fields with low-variability.
- Your clean data set should have 13 columns where the Average of **Age Years** should be 36 (rounded up)

Note: *For the sake of consistency in the data cleanup process, impute data using the median of the entire data field instead of removing a few data points. (100 word limit)*

Note: *For students using software other than Alteryx, please format each variable as:*

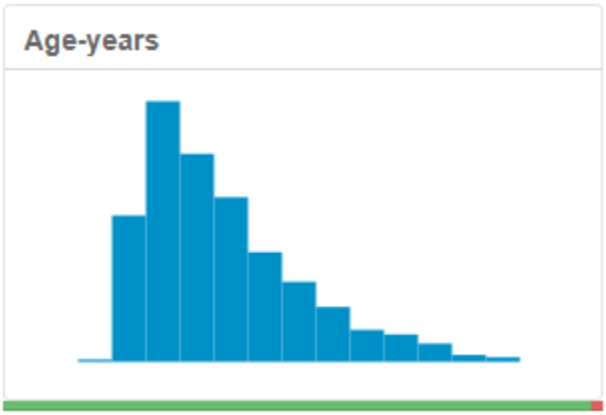
Variable	**Data Type**
Credit-Application-Result	String
Account-Balance	String
Duration-of-Credit-Month	Double
Payment-Status-of-Previous-Credit	String
Purpose	String
Credit-Amount	Double
Value-Savings-Stocks	String
Length-of-current-employment	String
Instalment-per-cent	Double
Guarantors	String
Duration-in-Current-address	Double
Most-valuable-available-asset	Double
Age-years	Double
Concurrent-Credits	String
Type-of-apartment	Double
No-of-Credits-at-this-Bank	String
Occupation	Double
No-of-dependents	Double
Telephone	Double
Foreign-Worker	Double

To achieve consistent results reviewers expect.

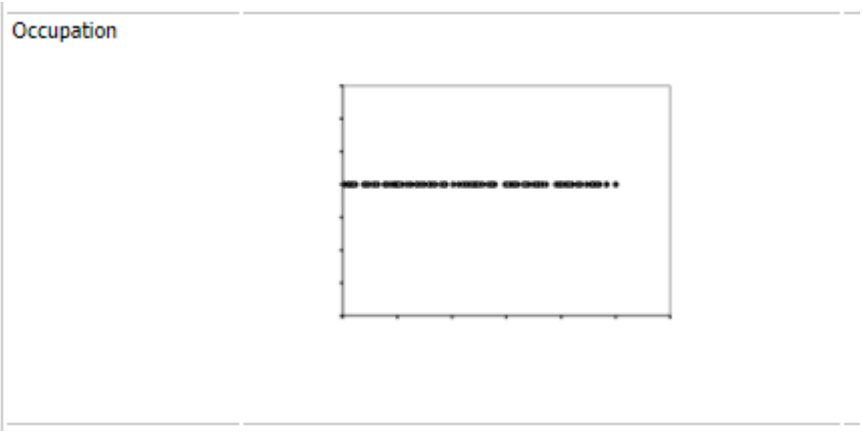
Answer this question:

- In your cleanup process, which fields did you remove or impute? Please justify why you removed or imputed these fields. Visualizations are encouraged.

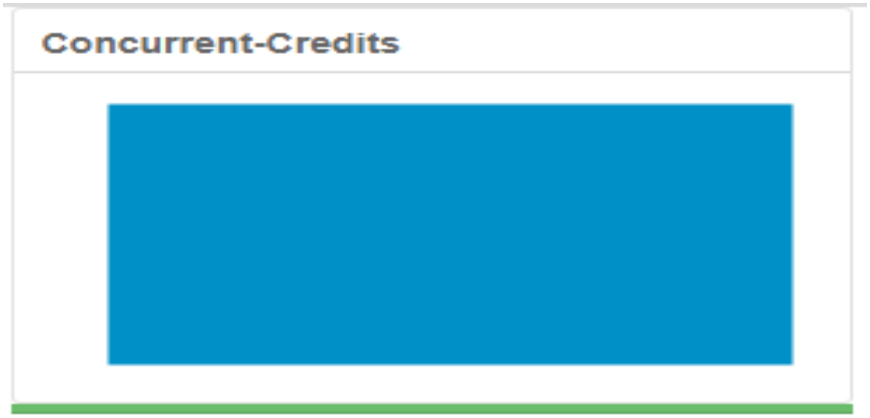
  Fields Imputed :-
  Age-years is imputed as it has 2% missing data. As it is right skewed median value is used for imputation as median value is less sensitive to skewness and outliers while mean will be pulled away from centre by extreme values.



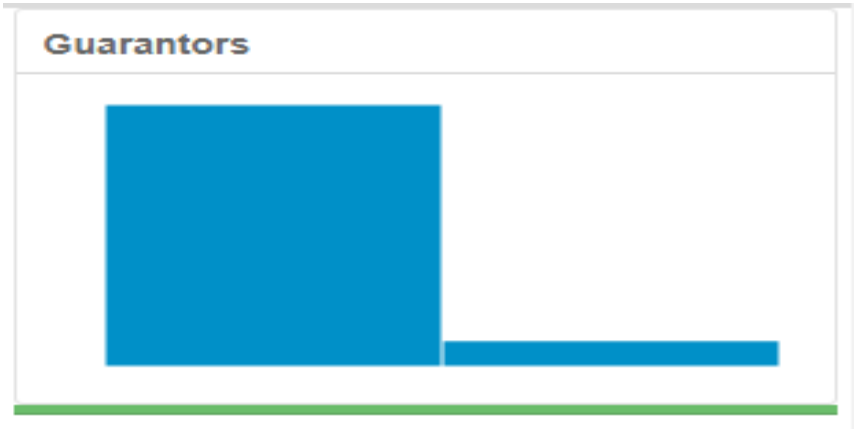
  Fields Removed:-
  Occupation has only single value 1. Due to low variability, it is removed.



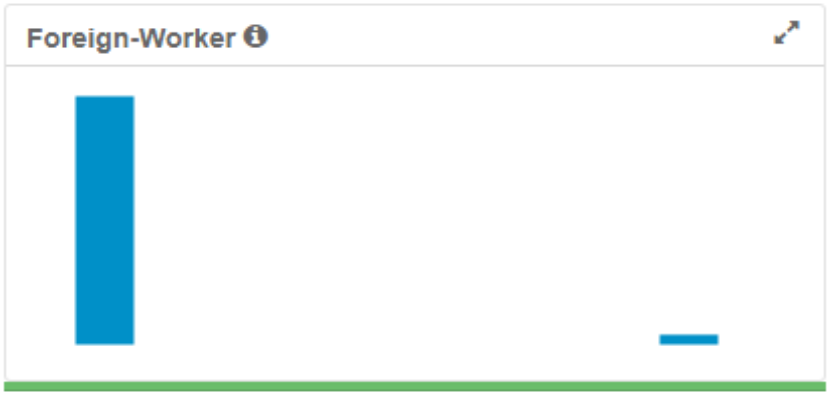
Concurrent-Credits has only one value Other Banks/Depts. Due to low variability, it is removed.



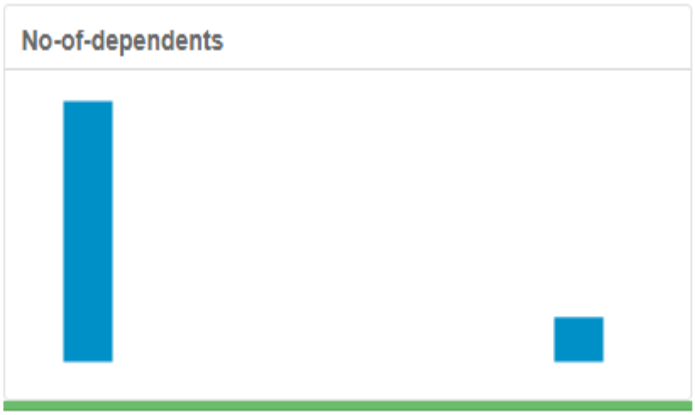
Guarantors: - Majority of values are None. Due to low variability, it is removed.



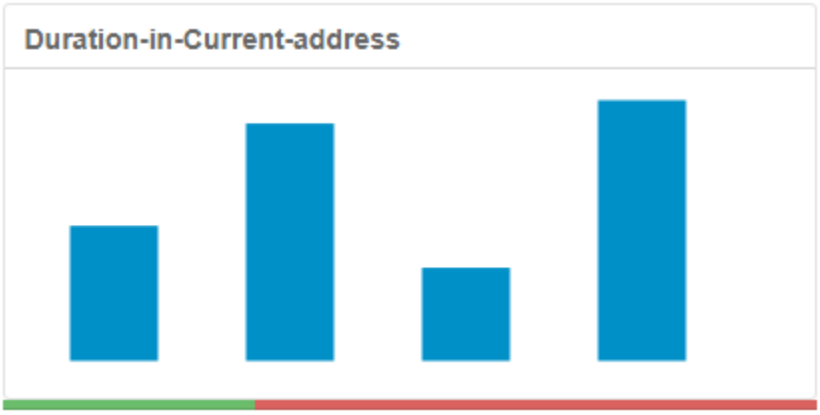
Foreign-Worker: - Majority of values are 1. Due to low variability, it is removed.



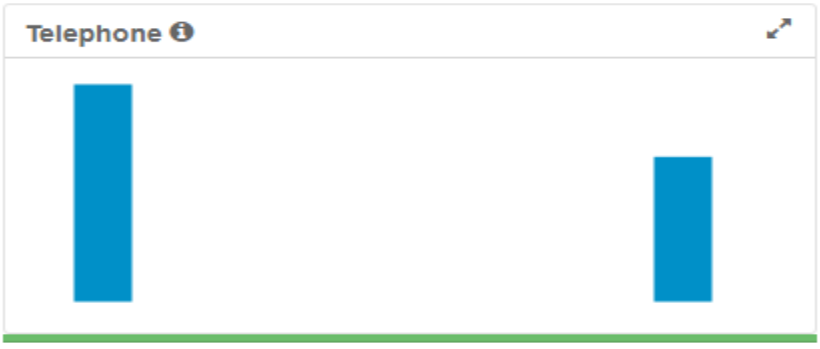
No-of-dependents: - Majority of values are 1. Due to low variability, it is removed.



Duration-in-Current-address: - has 69% missing values. So, it is removed.



Telephone: Owning a telephone is now common. This does not give any creditworthiness details to us.



Step 3: Train your Classification Models

First, create your Estimation and Validation samples where 70% of your dataset should go to Estimation and 30% of your entire dataset should be reserved for Validation. Set the Random Seed to 1.

Create all of the following models: Logistic Regression, Decision Tree, Forest Model, Boosted Model

*Answer these questions for **each model** you created:*

- Which predictor variables are significant or the most important? Please show the p-values or variable importance charts for all of your predictor variables.

  Logistic Regression

  The significant variables are Account.BalanceSome Balance, Payment.Status.of.Previous.CreditSome Problems, PurposeNew car, Credit.Amount, Length.of.current.employment< 1yr, Instalment.per.cent

Report for Logistic Regression Model Logistic_Regression_Stepwise

Basic Summary

Call:

```
glm(formula = Credit.Application.Result ~ Account.Balance + Payment.Status.of.Previous.Credit +
Purpose + Credit.Amount + Length.of.current.employment + Instalment.per.cent +
Most.valuable.available.asset, family = binomial(logit), data = the.data)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-2.289	-0.713	-0.448	0.722	2.454

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-2.9621914	6.837e-01	-4.3326	1e-05	***
Account.BalanceSome Balance	-1.6053228	3.067e-01	-5.2344	1.65e-07	***
Payment.Status.of.Previous.CreditPaid Up	0.2360857	2.977e-01	0.7930	0.42775	
Payment.Status.of.Previous.CreditSome Problems	1.2154514	5.151e-01	2.3595	0.0183	*
PurposeNew car	-1.6993164	6.142e-01	-2.7668	0.00566	**
PurposeOther	-0.3257637	8.179e-01	-0.3983	0.69042	
PurposeUsed car	-0.7645820	4.004e-01	-1.9096	0.05618	.
Credit.Amount	0.0001704	5.733e-05	2.9716	0.00296	**
Length.of.current.employment4-7 yrs	0.3127022	4.587e-01	0.6817	0.49545	
Length.of.current.employment< 1yr	0.8125785	3.874e-01	2.0973	0.03596	*
Instalment.per.cent	0.3016731	1.350e-01	2.2340	0.02549	*
Most.valuable.available.asset	0.2650267	1.425e-01	1.8599	0.06289	.

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

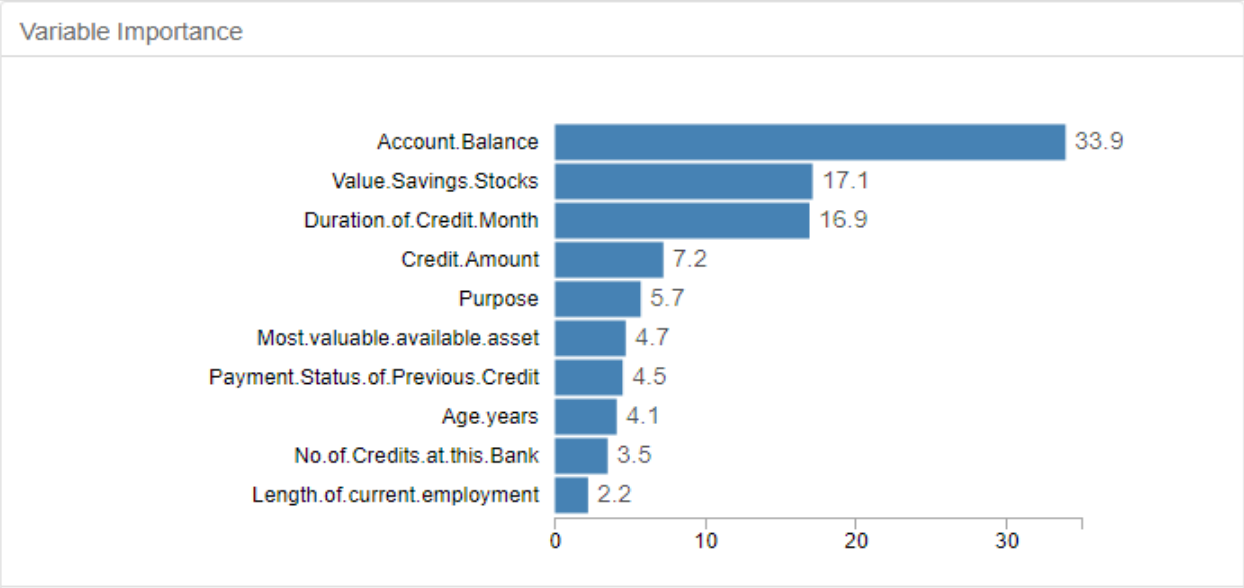
(Dispersion parameter for binomial taken to be 1)

Null deviance: 413.16 on 349 degrees of freedom
Residual deviance: 328.55 on 338 degrees of freedom
McFadden R-Squared: 0.2048, Akaike Information Criterion 352.5

Number of Fisher Scoring iterations: 5

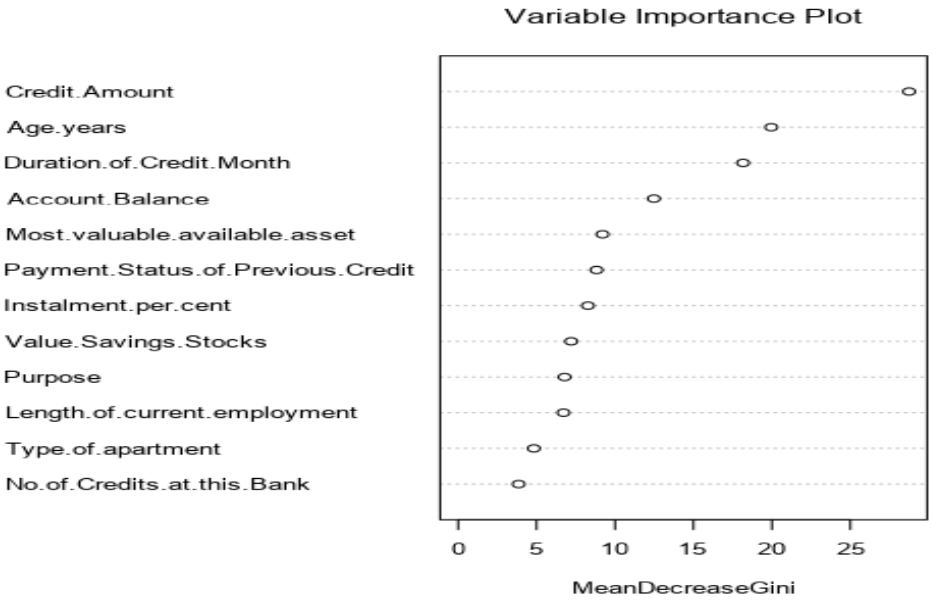
Decision Tree

The most important 3 variables are Account.Balance, Value.Savings.Stocks, Duration.of.Credit.Month.



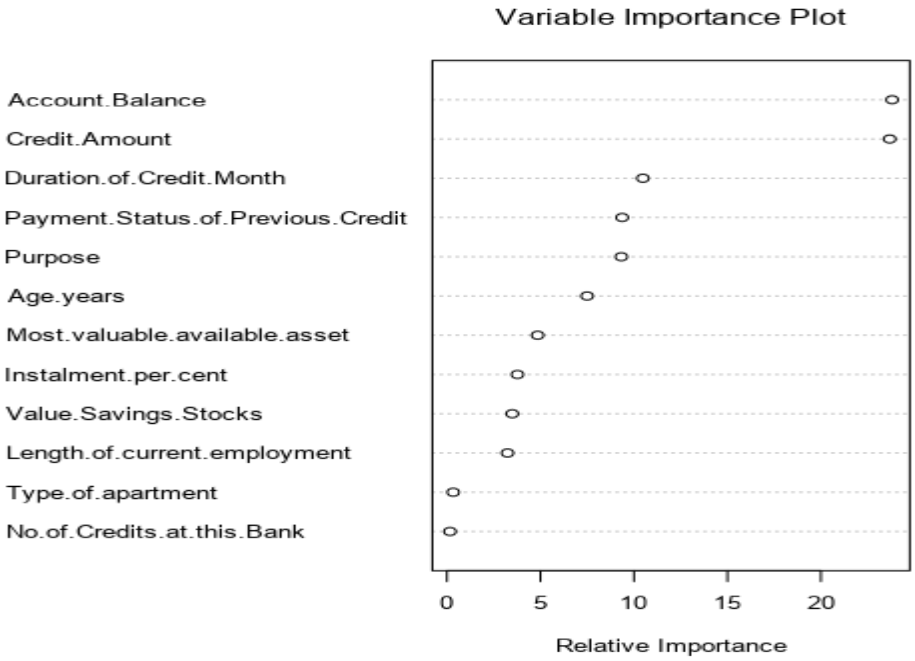
Forest Model

The most important 3 variables are Credit.Amount, Age.years, Duration.of.Credit.Month



Boosted Model

The most important 3 variables are Account.Balance, Credit.Amount, Duration.of.Credit.Month.



- Validate your model against the Validation set. What was the overall percent accuracy? Show the confusion matrix. Are there any bias seen in the model's predictions?

From model comparison report the accuracy of logistic regression model is 76%, Decision Tree model is 74.67%, Random Forest model is 79.33%, Boosted model is 78.67%.

Count of Actual credit worthy is more than actual non-credit worthy, which means we have an imbalanced data. Accuracy measure alone is not that good for imbalanced data. The calculated PPV and NPV values are not same, so bias exists in the model's prediction. For Random Forest model bias is medium, boosted model has less bias, logistic regression model and decision tree model has high bias.

	Logistic Regression TP = 92 TN = 22 FP = 23 FN = 13 Actual yes = 105 Actual no = 45 Predicted yes = 115 Predicted no = 35 Total = 300	**Decision Tree** TP = 93 TN = 19 FP = 26 FN = 12 Actual yes = 105 Actual no = 45 Predicted yes = 119 Predicted no = 31 Total = 300	**Random Forest** TP = 102 TN = 17 FP = 28 FN = 3 Actual yes = 105 Actual no = 45 Predicted yes = 130 Predicted no = 20 Total = 300	**Boosted Model** TP = 101 TN = 17 FP = 28 FN = 4 Actual yes = 105 Actual no = 45 Predicted yes = 129 Predicted no = 21 Total = 300
Accuracy (TP + TN)/Total	0.38	0.3733	0.3966	0.3933
Misclassification Rate (FP + FN)/Total	0.12	0.1266	0.1033	0.1066

True Positive Rate/Sensitivity/Recall TP/actual yes	0.8762	0.8857	0.9714	0.9619
False Positive Rate FP/actual no	0.5111	0.5777	0.6222	0.6222
True Negative Rate/Specificity TN/actual no	0.4888	0.4222	0.3777	0.3777
Precision/PPV TP/predicted yes	0.8	0.7815	0.7846	0.7829
Prevalence Actual yes/Total	0.35	0.35	0.35	0.35
NPV TN/(TN + FN)	0.6285	0.6129	0.85	0.8095

Model Comparison Report

Fit and error measures

Model	Accuracy	F1	AUC	Accuracy_Creditworthy	Accuracy_Non-Creditworthy
Decision_Tree	0.7467	0.8304	0.7035	0.8857	0.4222
Random_Forest	0.7933	0.8681	0.7368	0.9714	0.3778
Boosted_Model	0.7867	0.8632	0.7507	0.9619	0.3778
Logistic_Regression_Stepwise	0.7600	0.8364	0.7306	0.8762	0.4889

Model: model names in the current comparison.

Accuracy: overall accuracy, number of correct predictions of all classes divided by total sample number.

Accuracy_[class name]: accuracy of Class [class name] is defined as the number of cases that are **correctly** predicted to be Class [class name] divided by the total number of cases that actually belong to Class [class name], this measure is also known as *recall*.

AUC: area under the ROC curve, only available for two-class classification.

F1: F1 score, 2 * precision * recall / (precision + recall). The *precision* measure is the percentage of actual members of a class that were predicted to be in that class divided by the total number of cases predicted to be in that class. In situations where there are three or more classes, average precision and average recall values across classes are used to calculate the F1 score.

Confusion matrix of Boosted_Model

	Actual_Creditworthy	Actual_Non-Creditworthy
Predicted_Creditworthy	101	28
Predicted_Non-Creditworthy	4	17

Confusion matrix of Decision_Tree

	Actual_Creditworthy	Actual_Non-Creditworthy
Predicted_Creditworthy	93	26
Predicted_Non-Creditworthy	12	19

Confusion matrix of Logistic_Regression_Stepwise

	Actual_Creditworthy	Actual_Non-Creditworthy
Predicted_Creditworthy	92	23
Predicted_Non-Creditworthy	13	22

Confusion matrix of Random_Forest

	Actual_Creditworthy	Actual_Non-Creditworthy
Predicted_Creditworthy	102	28
Predicted_Non-Creditworthy	3	17

You should have four sets of questions answered. (500 word limit)

Step 4: Writeup

Decide on the best model and score your new customers. For reviewing consistency, if Score_Creditworthy is greater than Score_NonCreditworthy, the person should be labeled as "Creditworthy"

Write a brief report on how you came up with your classification model and write down how many of the new customers would qualify for a loan. (250 word limit)

Answer these questions:

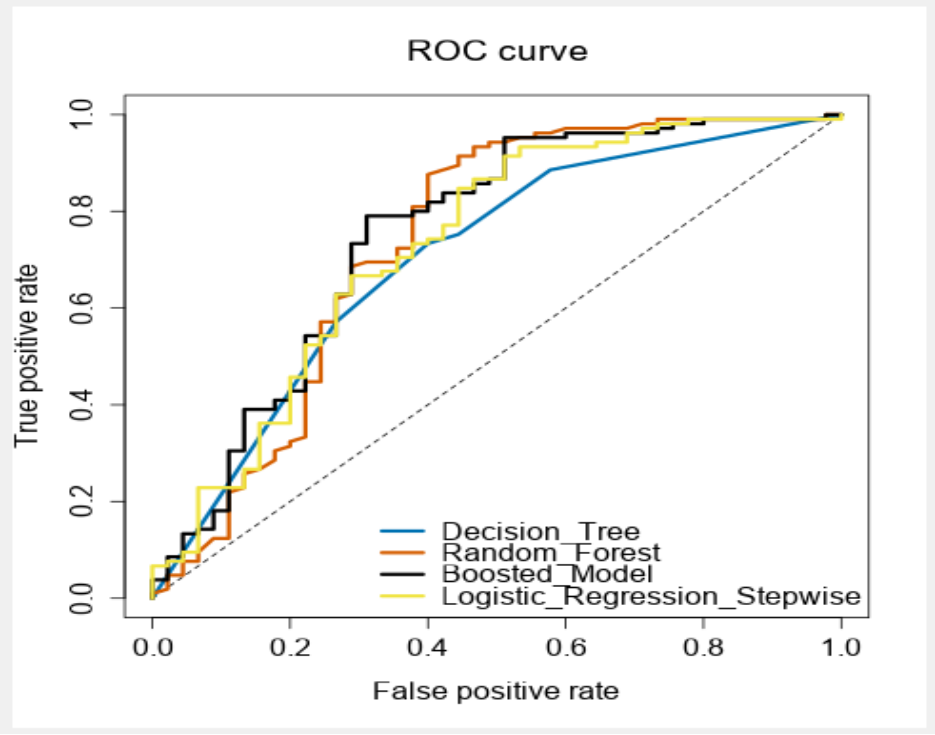
- Which model did you choose to use? Please justify your decision using **all** of the following techniques. Please only use these techniques to justify your decision:

  I choose to use the random forest model.

  - Overall Accuracy against your Validation set
    Random Forest model has 79.33% overall accuracy.

  - Accuracies within "Creditworthy" and "Non-Creditworthy" segments
    97.14% and 37.78%

  - ROC graph



The random forest model reaches the TPR fastest and reaches the top with AUC 0.7368.

- Bias in the Confusion Matrices.

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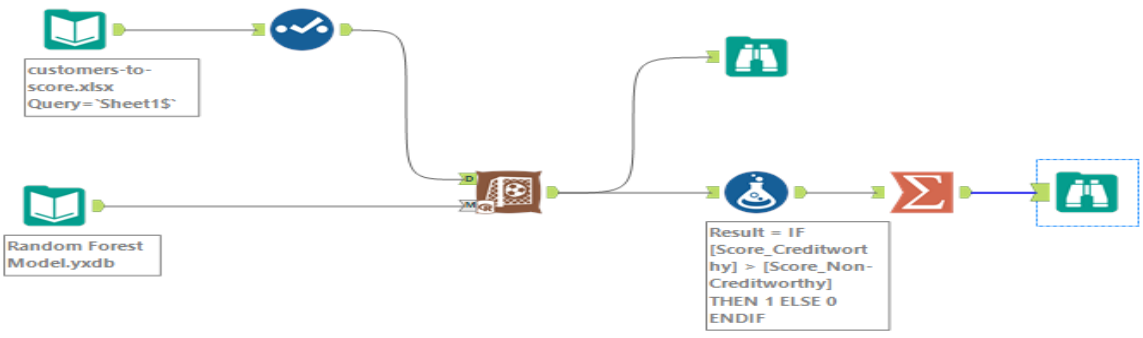
Prevalence Actual yes/Total	0.35	0.35	0.35	0.35
NPV TN/(TN + FN)	0.6285	0.6129	0.85	0.8095

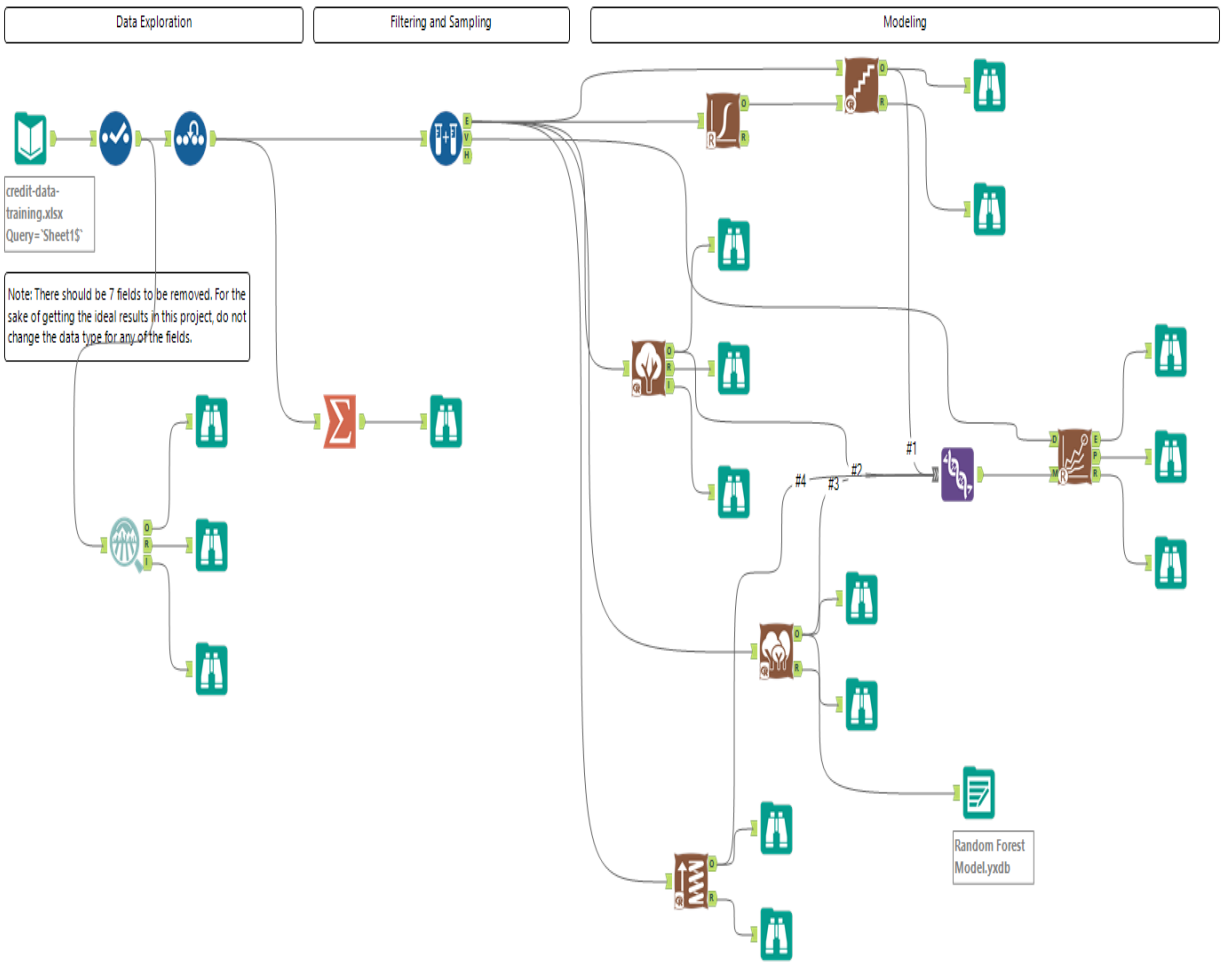
The random forest model's PPV = 0.7846 and NPV = 0.85, there exist medium bias.

Note: Remember that your boss only cares about prediction accuracy for Creditworthy and Non-Creditworthy segments.

- How many individuals are creditworthy?

  408 individuals are creditworthy.





Before you Submit

Please check your answers against the requirements of the project dictated by the rubric here. Reviewers will use this rubric to grade your project.