Caravan Insurance Potential Customer Identification - **Kathakali Seth**

Pre-Processing

***Import Libraries***

In [1]:

import numpy as np

import pandas as pd

from pandas.io.parsers import read\_csv

from sklearn.cross\_validation import train\_test\_split

from sklearn.metrics import classification\_report

from sklearn.metrics import confusion\_matrix

from sklearn.metrics import accuracy\_score

from sklearn import preprocessing

from imblearn.over\_sampling import SMOTE # For Oversampling

#from outliers import smirnov\_grubbs as grubbs

from sklearn.feature\_selection import SelectKBest

from sklearn.feature\_selection import chi2

from sklearn.cluster import KMeans

from sklearn.decomposition import PCA

from sklearn.naive\_bayes import GaussianNB, BernoulliNB

from sklearn.linear\_model import LogisticRegression

from sklearn.tree import DecisionTreeClassifier

from sklearn.neural\_network import \*

from sklearn.ensemble import RandomForestClassifier

from sklearn.ensemble import AdaBoostClassifier

from sklearn.ensemble import GradientBoostingClassifier

from sklearn.ensemble import ExtraTreesClassifier

from sklearn.svm import SVC

import matplotlib.pyplot as plt

%pylab inline

import seaborn as sns

Populating the interactive namespace from numpy and matplotlib

/opt/conda/lib/python3.6/site-packages/sklearn/cross\_validation.py:41: DeprecationWarning: This module was deprecated in version 0.18 in favor of the model\_selection module into which all the refactored classes and functions are moved. Also note that the interface of the new CV iterators are different from that of this module. This module will be removed in 0.20.

"This module will be removed in 0.20.", DeprecationWarning)

***Read and Partition Data***

In [2]:

dataset = read\_csv('../input/caravan-insurance-challenge.csv')

var=16

print(dataset.describe())

print('Variables selected : ', list(dataset.columns.values[[3,10,16,25,29,31,33,40,41,42,43,44,47,59,61,68]]))

selected = dataset.columns.values[[3,10,16,25,29,31,33,40,41,42,43,44,47,59,61,68]]

X = (dataset[dataset.columns[[3,10,16,25,29,31,33,40,41,42,43,44,47,59,61,68]]].values)

# Normalization - Using MinMax Scaler

min\_max\_scaler = preprocessing.MinMaxScaler()

X = min\_max\_scaler.fit\_transform(X)

y = np.vstack(dataset['CARAVAN'].values)

print('**\n**')

print('X and y Input Data: ', X.shape, y.shape)

X\_train\_original, X\_test2, y\_train\_original, y\_test2 = train\_test\_split(X, y, test\_size=0.3,

random\_state=42)

print('Training Set Shape: ', X\_train\_original.shape, y\_train\_original.shape)

X\_val, X\_test, y\_val, y\_test = train\_test\_split(X\_test2, y\_test2, test\_size=0.33,random\_state=42)

# Used Seed in Partitioning so that Test Set remains same for every Run

print('Validation Set Shape: ', X\_val.shape,y\_val.shape)

print('Test Set Shape: ', X\_test.shape, y\_test.shape)

MOSTYPE MAANTHUI MGEMOMV MGEMLEEF MOSHOOFD \

count 9822.000000 9822.000000 9822.000000 9822.000000 9822.000000

mean 24.253207 1.108735 2.677561 2.996437 5.779067

std 12.918058 0.412101 0.780701 0.804660 2.874148

min 1.000000 1.000000 1.000000 1.000000 1.000000

25% 10.000000 1.000000 2.000000 2.000000 3.000000

50% 30.000000 1.000000 3.000000 3.000000 7.000000

75% 35.000000 1.000000 3.000000 3.000000 8.000000

max 41.000000 10.000000 6.000000 6.000000 10.000000

MGODRK MGODPR MGODOV MGODGE MRELGE \

count 9822.000000 9822.000000 9822.000000 9822.000000 9822.000000

mean 0.700672 4.637650 1.050092 3.262981 6.188964

std 1.015107 1.721212 1.011156 1.606287 1.896070

min 0.000000 0.000000 0.000000 0.000000 0.000000

25% 0.000000 4.000000 0.000000 2.000000 5.000000

50% 0.000000 5.000000 1.000000 3.000000 6.000000

75% 1.000000 6.000000 2.000000 4.000000 7.000000

max 9.000000 9.000000 5.000000 9.000000 9.000000

... APERSONG AGEZONG AWAOREG ABRAND \

count ... 9822.000000 9822.000000 9822.000000 9822.000000

mean ... 0.004582 0.007941 0.004276 0.574018

std ... 0.067535 0.088764 0.071224 0.561255

min ... 0.000000 0.000000 0.000000 0.000000

25% ... 0.000000 0.000000 0.000000 0.000000

50% ... 0.000000 0.000000 0.000000 1.000000

75% ... 0.000000 0.000000 0.000000 1.000000

max ... 1.000000 1.000000 2.000000 7.000000

AZEILPL APLEZIER AFIETS AINBOED ABYSTAND \

count 9822.000000 9822.000000 9822.00000 9822.000000 9822.000000

mean 0.000916 0.005091 0.03146 0.008450 0.013846

std 0.030258 0.077996 0.20907 0.092647 0.117728

min 0.000000 0.000000 0.00000 0.000000 0.000000

25% 0.000000 0.000000 0.00000 0.000000 0.000000

50% 0.000000 0.000000 0.00000 0.000000 0.000000

75% 0.000000 0.000000 0.00000 0.000000 0.000000

max 1.000000 2.000000 4.00000 2.000000 2.000000

CARAVAN

count 9822.000000

mean 0.059662

std 0.236872

min 0.000000

25% 0.000000

50% 0.000000

75% 0.000000

max 1.000000

[8 rows x 86 columns]

Variables selected : ['MGEMOMV', 'MRELGE', 'MOPLHOOG', 'MSKA', 'MSKD', 'MHKOOP', 'MAUT2', 'MINK7512', 'MINK123M', 'MINKGEM', 'MKOOPKLA', 'PWAPART', 'PPERSAUT', 'PBRAND', 'PPLEZIER', 'APERSAUT']

X and y Input Data: (9822, 16) (9822, 1)

Training Set Shape: (6875, 16) (6875, 1)

Validation Set Shape: (1974, 16) (1974, 1)

Test Set Shape: (973, 16) (973, 1)

/opt/conda/lib/python3.6/site-packages/sklearn/utils/validation.py:444: DataConversionWarning: Data with input dtype int64 was converted to float64 by MinMaxScaler.

warnings.warn(msg, DataConversionWarning)

***Outlier Detection***

In [3]:

#for i in range(var):

# print((grubbs.test(X\_train[:,i], alpha=0.025).reshape(-1)).shape)

***Oversampling of underrepresented class***

In [4]:

doOversampling = True

if doOversampling:

# Apply regular SMOTE

sm = SMOTE(kind='regular')

X\_train, y\_train = sm.fit\_sample(X\_train\_original, y\_train\_original)

print('Training Set Shape after oversampling: ', X\_train.shape, y\_train.shape)

print(pd.crosstab(y\_train,y\_train))

else:

X\_train = X\_train\_original

y\_train = y\_train\_original

Training Set Shape after oversampling: (12942, 16) (12942,)

col\_0 0 1

row\_0

0 6471 0

1 0 6471

/opt/conda/lib/python3.6/site-packages/sklearn/utils/validation.py:547: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

y = column\_or\_1d(y, warn=True)

***Scatterplot for Variable Selection***

In [5]:

# Plot the feature importances of the forest

*'''*

*plt.figure(figsize=(6 \* 2, 2.4 \* int(var/2+.5)))*

*plt.subplots\_adjust(bottom=0, left=.01, right=.99, top=.90, hspace=.35)*

*plt.title("Variable Co-relation with Outcome",size=20)*

*for i in range(var):*

*plt.subplot(8, 2, i+1)*

*plt.title(selected[i], size=9,color='darkslateblue',fontweight='bold')*

*plt.scatter(range(len(X)),X[:,i], s=40, marker= 'o',c=((y[:,0:1])+20).reshape(-1), alpha=0.5)*

*plt.yticks()*

*plt.xticks()*

*plt.show()*

*'''*

Out[5]:

'\nplt.figure(figsize=(6 \* 2, 2.4 \* int(var/2+.5)))\nplt.subplots\_adjust(bottom=0, left=.01, right=.99, top=.90, hspace=.35)\nplt.title("Variable Co-relation with Outcome",size=20)\nfor i in range(var):\n plt.subplot(8, 2, i+1)\n plt.title(selected[i], size=9,color=\'darkslateblue\',fontweight=\'bold\')\n plt.scatter(range(len(X)),X[:,i], s=40, marker= \'o\',c=((y[:,0:1])+20).reshape(-1), alpha=0.5)\n plt.yticks()\n plt.xticks()\nplt.show()\n'

***Feature Reduction thru PCA - Not used in final phase***

In [6]:

doPCA = False

if doPCA:

pca = PCA(svd\_solver='randomized',n\_components=10,random\_state=42).fit(X\_train)

X\_train = pca.transform(X\_train)

X\_val = pca.transform(X\_val)

#print(pca.components\_)

#print(pca.explained\_variance\_)

#print(pca.explained\_variance\_ratio\_)

#print(pca.mean\_)

print(pca.n\_components\_)

print(pca.noise\_variance\_)

plt.figure(1, figsize=(8, 4.5))

plt.clf()

plt.axes([.2, .2, .7, .7])

plt.plot(pca.explained\_variance\_, linewidth=2)

plt.axis('tight')

plt.xlabel('n\_components')

plt.ylabel('explained\_variance\_')

plt.show()

else:

X\_train = X\_train

X\_val = X\_val

***Flag for Final Run***

In [7]:

Final\_Run = True # Will Not Process Test Set if value is False

Build Models

***Decision Tree Classifier***

In [8]:

clf\_DT = DecisionTreeClassifier(criterion='gini', splitter='best', max\_depth=10,

min\_samples\_split=2, min\_samples\_leaf=1,

min\_weight\_fraction\_leaf=0.0, max\_features=None,

max\_leaf\_nodes=None, min\_impurity\_split=1e-07)

clf\_DT.fit(X\_train, y\_train)

y\_pred\_DT = clf\_DT.predict(X\_val)

/opt/conda/lib/python3.6/site-packages/sklearn/tree/tree.py:282: DeprecationWarning: The min\_impurity\_split parameter is deprecated and will be removed in version 0.21. Use the min\_impurity\_decrease parameter instead.

DeprecationWarning)

***Naive Bayes Classifier***

In [9]:

clf\_NB = BernoulliNB()

clf\_NB.fit(X\_train, y\_train)

y\_pred\_NB = clf\_NB.predict(X\_val)

#print(clf\_NB.predict\_proba(X\_val))

***Neural Network Classifier***

In [10]:

MLPClassifier(activation='relu', alpha=1e-05,

batch\_size='auto', beta\_1=0.9, beta\_2=0.999, early\_stopping=False,

epsilon=1e-08, hidden\_layer\_sizes=(64), learning\_rate='constant',

learning\_rate\_init=0.001, max\_iter=2000, momentum=0.9,

nesterovs\_momentum=True, power\_t=0.5, random\_state=42, shuffle=True,

tol=0.001, validation\_fraction=0.1, verbose=True,

warm\_start=False)

clf\_MLP = MLPClassifier(alpha=1e-05, hidden\_layer\_sizes=(64))

clf\_MLP.fit(X\_train, y\_train)

y\_pred\_MLP = clf\_MLP.predict(X\_val)

/opt/conda/lib/python3.6/site-packages/sklearn/neural\_network/multilayer\_perceptron.py:564: ConvergenceWarning: Stochastic Optimizer: Maximum iterations (200) reached and the optimization hasn't converged yet.

% self.max\_iter, ConvergenceWarning)

***Logistic Regression Classifier***

In [11]:

#clf\_Log = LogisticRegression(solver='sag', max\_iter=1000, random\_state=42,verbose=2)

clf\_Log = LogisticRegression(solver='liblinear', max\_iter=1000,

random\_state=42,verbose=2,class\_weight='balanced')

clf\_Log.fit(X\_train, y\_train)

y\_pred\_Log = clf\_Log.predict(X\_val)

print(clf\_Log.coef\_)

print(clf\_Log.intercept\_)

[LibLinear][[-0.17640435 1.44808526 1.13341323 -0.93670851 -0.00644546 0.29440906

-1.22798225 -0.9000692 -2.10973227 1.26207723 0.7277482 0.62904159

1.68024344 0.75129525 3.91135916 0.44253678]]

[-2.94462269]

***Random Forest Classifier***

In [12]:

clf\_RF = RandomForestClassifier(n\_estimators=500, criterion='gini', max\_depth=15,

min\_samples\_split=2, min\_samples\_leaf=1, min\_weight\_fraction\_leaf=0.0,

max\_features='auto', max\_leaf\_nodes=None, min\_impurity\_split=1e-07,

bootstrap=True, oob\_score=False, n\_jobs=1,

random\_state=42, verbose=1, warm\_start=False, class\_weight=None)

clf\_RF.fit(X\_train, y\_train)

y\_pred\_RF = clf\_RF.predict(X\_val)

/opt/conda/lib/python3.6/site-packages/sklearn/tree/tree.py:282: DeprecationWarning: The min\_impurity\_split parameter is deprecated and will be removed in version 0.21. Use the min\_impurity\_decrease parameter instead.

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/opt/conda/lib/python3.6/site-packages/sklearn/tree/tree.py:282: DeprecationWarning: The min\_impurity\_split parameter is deprecated and will be removed in version 0.21. Use the min\_impurity\_decrease parameter instead.

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DeprecationWarning)

/opt/conda/lib/python3.6/site-packages/sklearn/tree/tree.py:282: DeprecationWarning: The min\_impurity\_split parameter is deprecated and will be removed in version 0.21. Use the min\_impurity\_decrease parameter instead.

DeprecationWarning)

[Parallel(n\_jobs=1)]: Done 500 out of 500 | elapsed: 6.7s finished

[Parallel(n\_jobs=1)]: Done 500 out of 500 | elapsed: 0.2s finished

***AdaBoost Classifier***

In [13]:

clf\_AdaB = AdaBoostClassifier(n\_estimators=100)

clf\_AdaB.fit(X\_train, y\_train)

y\_pred\_AdaB = clf\_AdaB.predict(X\_val)

***Gradient Boost Classifier***

In [14]:

clf\_GB = GradientBoostingClassifier(n\_estimators=100, learning\_rate=1.0, random\_state=42)

clf\_GB.fit(X\_train, y\_train)

y\_pred\_GB = clf\_GB.predict(X\_val)

***Extra Tree Classifier***

In [15]:

clf\_ET = ExtraTreesClassifier(n\_estimators=250, random\_state=42)

clf\_ET.fit(X\_train, y\_train)

y\_pred\_ET = clf\_ET.predict(X\_val)

***SVM Classifier***

In [16]:

clf\_SVM = SVC(C=10, class\_weight='balanced', gamma='auto', kernel='rbf',

max\_iter=-1, probability=True, random\_state=42, verbose=True)

clf\_SVM.fit(X\_train, y\_train)

y\_pred\_SVM = clf\_SVM.predict(X\_val)

[LibSVM]

In [17]:

y\_val = y\_val.reshape(-1)

Model Performance Comparison

***Compare Accuracy of Models on Validation Set***

In [18]:

print(' Accuracy of Models ')

print('--------------------------------')

print('Decision Tree '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_DT)\*100)+'%')

print('Naive Bayes '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_NB)\*100)+'%')

print('Neural Network '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_MLP)\*100)+'%')

print('Logistic Regression '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_Log)\*100)+'%')

print('Random Forest '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_RF)\*100)+'%')

print('AdaBoost '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_AdaB)\*100)+'%')

print('GradientBoost '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_GB)\*100)+'%')

print('Extra Tree '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_ET)\*100)+'%')

print('Support Vector Machine '+"**{:.2f}**".format(accuracy\_score(y\_val, y\_pred\_SVM)\*100)+'%')

Accuracy of Models

--------------------------------

Decision Tree 84.50%

Naive Bayes 66.92%

Neural Network 76.19%

Logistic Regression 66.87%

Random Forest 92.20%

AdaBoost 90.88%

GradientBoost 92.71%

Extra Tree 92.10%

Support Vector Machine 71.53%

***Print Confusion Matrix for all Models***

In [19]:

print('Decision Tree ')

cm\_DT = confusion\_matrix(y\_val,y\_pred\_DT)

print(cm\_DT)

print('**\n**')

print('Naive Bayes ')

cm\_NB = confusion\_matrix(y\_val,y\_pred\_NB)

print(cm\_NB)

print('**\n**')

print('Neural Network ')

cm\_MLP = confusion\_matrix(y\_val,y\_pred\_MLP)

print(cm\_MLP)

print('**\n**')

print('Logistic Regression ')

cm\_Log = confusion\_matrix(y\_val,y\_pred\_Log)

print(cm\_Log)

print('**\n**')

print('Random Forest ')

cm\_RF = confusion\_matrix(y\_val,y\_pred\_RF)

print(cm\_RF)

print('**\n**')

print('AdaBoost ')

cm\_AdaB = confusion\_matrix(y\_val,y\_pred\_AdaB)

print(cm\_AdaB)

print('**\n**')

print('GradientBoost ')

cm\_GB = confusion\_matrix(y\_val,y\_pred\_GB)

print(cm\_GB)

print('**\n**')

print('Extra Tree ')

cm\_ET = confusion\_matrix(y\_val,y\_pred\_ET)

print(cm\_ET)

print('**\n**')

print('SVM ')

cm\_SVM = confusion\_matrix(y\_val,y\_pred\_SVM)

print(cm\_SVM)

Decision Tree

[[1628 231]

[ 75 40]]

Naive Bayes

[[1256 603]

[ 50 65]]

Neural Network

[[1451 408]

[ 62 53]]

Logistic Regression

[[1244 615]

[ 39 76]]

Random Forest

[[1804 55]

[ 99 16]]

AdaBoost

[[1777 82]

[ 98 17]]

GradientBoost

[[1820 39]

[ 105 10]]

Extra Tree

[[1809 50]

[ 106 9]]

SVM

[[1340 519]

[ 43 72]]

Test Set Results

***Compare Models on Training, Validation and Test Set Results***

***Execute only on Final Run***

In [20]:

if Final\_Run:

if doPCA:

X\_test = pca.transform(X\_test)

X\_train\_original = pca.transform(X\_train\_original)

y\_test = y\_test.reshape(-1)

y\_train\_original = y\_train\_original.reshape(-1)

y\_pred\_train\_DT = clf\_DT.predict(X\_train\_original)

y\_pred\_train\_NB = clf\_NB.predict(X\_train\_original)

y\_pred\_train\_MLP = clf\_MLP.predict(X\_train\_original)

y\_pred\_train\_Log = clf\_Log.predict(X\_train\_original)

y\_pred\_test\_DT = clf\_DT.predict(X\_test)

y\_pred\_test\_NB = clf\_NB.predict(X\_test)

y\_pred\_test\_MLP = clf\_MLP.predict(X\_test)

y\_pred\_test\_Log = clf\_Log.predict(X\_test)

cm\_DT\_train = confusion\_matrix(y\_train\_original,y\_pred\_train\_DT)

cm\_NB\_train = confusion\_matrix(y\_train\_original,y\_pred\_train\_NB)

cm\_MLP\_train = confusion\_matrix(y\_train\_original,y\_pred\_train\_MLP)

cm\_Log\_train = confusion\_matrix(y\_train\_original,y\_pred\_train\_Log)

cm\_DT\_test = confusion\_matrix(y\_test,y\_pred\_test\_DT)

cm\_NB\_test = confusion\_matrix(y\_test,y\_pred\_test\_NB)

cm\_MLP\_test = confusion\_matrix(y\_test,y\_pred\_test\_MLP)

cm\_Log\_test = confusion\_matrix(y\_test,y\_pred\_test\_Log)

print('Decision Tree Classification Matrix ')

print('Training')

print(cm\_DT\_train)

print('Validation')

print(cm\_DT)

print('Test')

print(cm\_DT\_test)

print('**\n**')

print('Naive Bayes Classification Matrix ')

print('Training')

print(cm\_NB\_train)

print('Validation')

print(cm\_NB)

print('Test')

print(cm\_NB\_test)

print('**\n**')

print('Neural Network Classification Matrix ')

print('Training')

print(cm\_MLP\_train)

print('Validation')

print(cm\_MLP)

print('Test')

print(cm\_MLP\_test)

print('**\n**')

print('Logistic Regression Classification Matrix ')

print('Training')

print(cm\_Log\_train)

print('Validation')

print(cm\_Log)

print('Test')

print(cm\_Log\_test)

print('**\n**')

Decision Tree Classification Matrix

Training

[[5777 694]

[ 180 224]]

Validation

[[1628 231]

[ 75 40]]

Test

[[788 118]

[ 43 24]]

Naive Bayes Classification Matrix

Training

[[4447 2024]

[ 178 226]]

Validation

[[1256 603]

[ 50 65]]

Test

[[627 279]

[ 26 41]]

Neural Network Classification Matrix

Training

[[5090 1381]

[ 115 289]]

Validation

[[1451 408]

[ 62 53]]

Test

[[696 210]

[ 34 33]]

Logistic Regression Classification Matrix

Training

[[4361 2110]

[ 124 280]]

Validation

[[1244 615]

[ 39 76]]

Test

[[600 306]

[ 19 48]]

***Choose Final Model***

Choosing Decision Tree Model as Final Model due to Accuracy + Simplicity

In [21]:

clf = clf\_NB

***Execute only on Final Run***

In [22]:

importances\_RF = clf\_RF.feature\_importances\_

std = np.std([tree.feature\_importances\_ for tree **in** clf\_RF.estimators\_],

axis=0)

indices1 = np.argsort(importances\_RF[0:var])[::-1]

indices = indices1[0:var]

# Print the feature ranking

print("Feature ranking:")

for f **in** range(var):

print("**%d**. **%s** (**%f**)" % (f + 1, (dataset.columns.values[[3,10,16,25,29,31,33,40,41,42,43,44,47,59,61,68]]).reshape(-1)[indices[f]], importances\_RF[indices[f]]))

# Plot the feature importances of the forest

plt.figure(figsize=(14, 3))

plt.title("Most Important Features - Random Forest",size=20)

plt.bar(range(var), importances\_RF[indices],

color="#aa6d0a", yerr=std[indices], align="center")

plt.yticks(size=14)

plt.xticks(range(var), (dataset.columns.values[[3,10,16,25,29,31,33,40,41,42,43,44,47,59,61,68]]).reshape(-1)[indices],rotation='vertical',size=12,color="#201506")

plt.xlim([-1, var])

plt.show()

Feature ranking:

1. MINKGEM (0.113137)

2. PPERSAUT (0.108717)

3. MRELGE (0.084973)

4. MINK7512 (0.082481)

5. PBRAND (0.079520)

6. MOPLHOOG (0.073296)

7. MKOOPKLA (0.070555)

8. MGEMOMV (0.063955)

9. MSKA (0.059485)

10. MAUT2 (0.056644)

11. MHKOOP (0.050513)

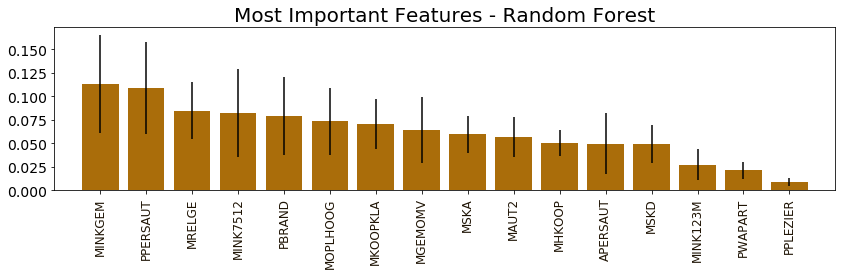
12. APERSAUT (0.049809)

13. MSKD (0.049474)

14. MINK123M (0.027458)

15. PWAPART (0.021237)

16. PPLEZIER (0.008747)



In [23]:

FN\_amount = -9950

TP\_amount = 9950

TN\_amount = 0

FP\_amount = -50

if Final\_Run:

print('Compare Profit from Models - Test Set')

print('-------------------------------------')

Profit\_DT = (cm\_DT\_test[0][0]\*TN\_amount + cm\_DT\_test[1][0]\*FN\_amount + cm\_DT\_test[0][1]\*FP\_amount +

cm\_DT\_test[1][1]\*TP\_amount)

print('Decision Tree Profit(Rs): ' + str(Profit\_DT))

Profit\_NB = (cm\_NB\_test[0][0]\*TN\_amount + cm\_NB\_test[1][0]\*FN\_amount + cm\_NB\_test[0][1]\*FP\_amount +

cm\_NB\_test[1][1]\*TP\_amount)

print('Naive Bayes Profit(Rs): ' + str(Profit\_NB))

Profit\_MLP = (cm\_MLP\_test[0][0]\*TN\_amount + cm\_MLP\_test[1][0]\*FN\_amount + cm\_MLP\_test[0][1]\*FP\_amount +

cm\_MLP\_test[1][1]\*TP\_amount)

print('Neural Network Profit(Rs): ' + str(Profit\_MLP))

Profit\_Log = (cm\_Log\_test[0][0]\*TN\_amount + cm\_Log\_test[1][0]\*FN\_amount + cm\_Log\_test[0][1]\*FP\_amount +

cm\_Log\_test[1][1]\*TP\_amount)

print('Logistic Regression Profit(Rs): ' + str(Profit\_Log))

y\_pred\_test = clf.predict(X\_test)

print('**\n\n**Best Model Accuracy on Test Set: '+"**{:.2f}**".format(accuracy\_score(y\_test, y\_pred\_test)\*100)+'%')

print('**\n**Confusion Matrix on Test Set ')

cm = confusion\_matrix(y\_test,y\_pred\_test)

print(cm)

print('**\n**')

Profit = cm[0][0]\*TN\_amount + cm[1][0]\*FN\_amount + cm[0][1]\*FP\_amount + cm[1][1]\*TP\_amount

print('Profit(Rs) for Test Set: ' + str(Profit))

# Checked Actual Positive and Negative Class in Test Set

Max\_Profit = 146\*TN\_amount + 0\*FN\_amount + 0\*FP\_amount + 4\*TP\_amount

print('Max\_Profit = ' + str(Max\_Profit))

print('**\n**')

print('Test Set Profit % w.r.t Maximum Profit: ' + "**{:.2f}**".format(float(Profit)/Max\_Profit\*100)+'%')

print('**\n**')

print('Final Model')

print('-----------')

print(str(clf))

Compare Profit from Models - Test Set

-------------------------------------

Decision Tree Profit(Rs): -194950

Naive Bayes Profit(Rs): 135300

Neural Network Profit(Rs): -20450

Logistic Regression Profit(Rs): 273250

Best Model Accuracy on Test Set: 68.65%

Confusion Matrix on Test Set

[[627 279]

[ 26 41]]

Profit(Rs) for Test Set: 135300

Max\_Profit = 39800

Test Set Profit % w.r.t Maximum Profit: 339.95%

Final Model

-----------

BernoulliNB(alpha=1.0, binarize=0.0, class\_prior=None, fit\_prior=True)

In [24]:

print(str(clf\_DT));print('**\n**')

print(str(clf\_NB));print('**\n**')

print(str(clf\_MLP));print('**\n**')

print(str(clf\_Log));print('**\n**')

print(str(clf\_RF));print('**\n**')

print(str(clf\_AdaB));print('**\n**')

print(str(clf\_GB));print('**\n**')

print(str(clf\_ET));print('**\n**')

print(str(clf\_SVM));print('**\n**')

DecisionTreeClassifier(class\_weight=None, criterion='gini', max\_depth=10,

max\_features=None, max\_leaf\_nodes=None,

min\_impurity\_decrease=0.0, min\_impurity\_split=1e-07,

min\_samples\_leaf=1, min\_samples\_split=2,

min\_weight\_fraction\_leaf=0.0, presort=False, random\_state=None,

splitter='best')

BernoulliNB(alpha=1.0, binarize=0.0, class\_prior=None, fit\_prior=True)

MLPClassifier(activation='relu', alpha=1e-05, batch\_size='auto', beta\_1=0.9,

beta\_2=0.999, early\_stopping=False, epsilon=1e-08,

hidden\_layer\_sizes=64, learning\_rate='constant',

learning\_rate\_init=0.001, max\_iter=200, momentum=0.9,

nesterovs\_momentum=True, power\_t=0.5, random\_state=None,

shuffle=True, solver='adam', tol=0.0001, validation\_fraction=0.1,

verbose=False, warm\_start=False)

LogisticRegression(C=1.0, class\_weight='balanced', dual=False,

fit\_intercept=True, intercept\_scaling=1, max\_iter=1000,

multi\_class='ovr', n\_jobs=1, penalty='l2', random\_state=42,

solver='liblinear', tol=0.0001, verbose=2, warm\_start=False)

RandomForestClassifier(bootstrap=True, class\_weight=None, criterion='gini',

max\_depth=15, max\_features='auto', max\_leaf\_nodes=None,

min\_impurity\_decrease=0.0, min\_impurity\_split=1e-07,

min\_samples\_leaf=1, min\_samples\_split=2,

min\_weight\_fraction\_leaf=0.0, n\_estimators=500, n\_jobs=1,

oob\_score=False, random\_state=42, verbose=1, warm\_start=False)

AdaBoostClassifier(algorithm='SAMME.R', base\_estimator=None,

learning\_rate=1.0, n\_estimators=100, random\_state=None)

GradientBoostingClassifier(criterion='friedman\_mse', init=None,

learning\_rate=1.0, loss='deviance', max\_depth=3,

max\_features=None, max\_leaf\_nodes=None,

min\_impurity\_decrease=0.0, min\_impurity\_split=None,

min\_samples\_leaf=1, min\_samples\_split=2,

min\_weight\_fraction\_leaf=0.0, n\_estimators=100,

presort='auto', random\_state=42, subsample=1.0, verbose=0,

warm\_start=False)

ExtraTreesClassifier(bootstrap=False, class\_weight=None, criterion='gini',

max\_depth=None, max\_features='auto', max\_leaf\_nodes=None,

min\_impurity\_decrease=0.0, min\_impurity\_split=None,

min\_samples\_leaf=1, min\_samples\_split=2,

min\_weight\_fraction\_leaf=0.0, n\_estimators=250, n\_jobs=1,

oob\_score=False, random\_state=42, verbose=0, warm\_start=False)

SVC(C=10, cache\_size=200, class\_weight='balanced', coef0=0.0,

decision\_function\_shape='ovr', degree=3, gamma='auto', kernel='rbf',

max\_iter=-1, probability=True, random\_state=42, shrinking=True,

tol=0.001, verbose=True)

In [25]: