CreditScore Data Set

Models will be fitted

1. Logistic Regression
2. SVM
3. Random Forest
4. ElasticNet
5. Ensumble These 4 Models

In [1]:
```
#Import Libraries
import csv
import numpy as np
import pandas as pd

### Import Descision Tree Classifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import ElasticNet
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.preprocessing import scale
from sklearn.decomposition import PCA
from sklearn import svm
from sklearn.ensemble import VotingClassifier

from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import roc_auc_score
from sklearn.pipeline import Pipeline
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix

# Perform the necessary imports
import matplotlib.pyplot as plt
## for pearsonr correlation just feed x and y to this
from scipy.stats import pearsonr
pd.options.display.max_columns=60
#Change the Number Fromat of DATA frame
pd.options.display.float_format = '{:,.4f}'.format
```

In [2]:
```
### Load the Data
seed=42
path="C:\\Users\\fbaharkoush\\IE 598 Machine Learning\\Homework\\Group Project\\"
df_credit=pd.read_csv(path+"MLF_GP1_CreditScore.csv")
if df_credit.isnull().sum().sum()==0:
    print("No Missing Values in the dataset")
```

```
No Missing Values in the dataset
```

In [3]:
```
### Get the dummy variables of Rating and merge it with the dataset
df_credit_dummies=pd.merge(df_credit.reset_index(),
         pd.get_dummies(df_credit["Rating"]).reset_index(),
        left_on="index",right_on="index",how="left").drop("index",axis=1)
```

In [4]:
```
df_credit_dummies.head(2)
```

Out[4]:

	Sales/Revenues	Gross Margin	EBITDA	EBITDA Margin	Net Income Before Extras	Total Debt	Net Debt	LT Debt	ST Debt	Cash	Free Cash Flow	De
0	-0.0055	0.0308	0.0189	0.0245	0.1468	-0.0297	-0.0193	-0.0426	0.0499	-0.1337	0.3530	
1	-0.0055	0.0308	0.0887	0.0947	0.1468	-0.0297	-0.0193	-0.0426	0.0499	-0.1337	0.3530	

In [5]:
```
### X and y
X=scale(df_credit_dummies.drop(['InvGrd', 'Rating'],axis=1).values)
y=df_credit_dummies["InvGrd"].values
### Train and Test
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.25,random_state=seed)
```

PCA with Dummy Variables

In [6]:
```
# Create PCA instance: model
pca_model = PCA()
### Fit the Features value to PCA
pca_model.fit_transform(X)
```

Out[6]:
```
array([[-1.15248335e-01,  3.04056439e-02, -5.73625149e-02, ...,
        -1.98683295e-03,  1.21401142e-03, -2.07682906e-15],
       [-1.06970414e-01,  4.46568712e-02, -1.00024599e-02, ...,
        -2.10264952e-03,  4.68145873e-05, -1.09291666e-15],
       [-1.00726759e-01,  4.49912941e-02,  2.03696419e-02, ...,
        -7.42464244e-04,  4.08196549e-04,  4.80258635e-15],
       ...,
       [-1.64284497e-01, -6.88637238e-01, -5.71696306e-01, ...,
        -1.00729677e-03,  1.42029979e-03,  1.05203267e-15],
       [-1.02581361e-01, -7.12270022e-01, -6.22364252e-01, ...,
         7.70699272e-04, -1.54993582e-03,  4.80073863e-16],
       [-2.14992750e-01, -6.88032028e-01, -6.28300064e-01, ...,
         2.69455000e-03, -8.46058966e-04,  9.73895010e-17]])
```

In [7]:
```
X_features=list(df_credit_dummies.drop(['InvGrd', 'Rating'],axis=1).columns)
```

In [8]:
```
df_pca_exp_var=pd.DataFrame({"Features":X_features,
              "PCA_Exp_Var":pca_model.explained_variance_ratio_}).sort_values("PCA_Exp_V
df_pca_exp_var["Cummulative Exp Var"]=df_pca_exp_var["PCA_Exp_Var"].cumsum()
```

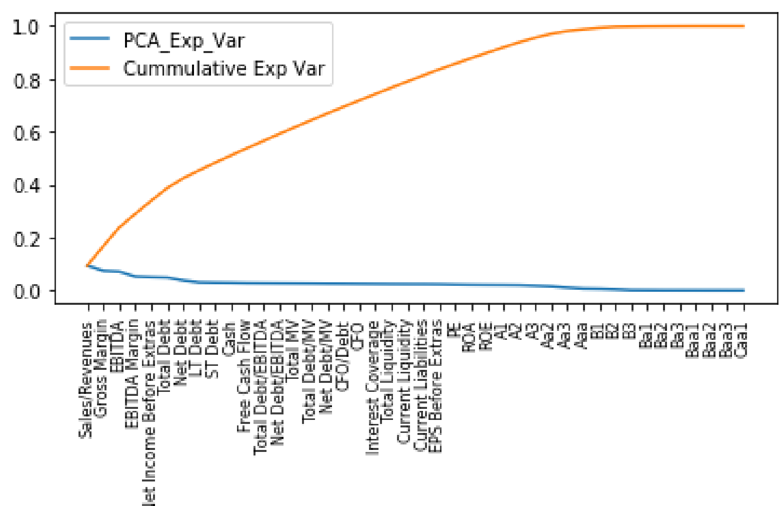
PCA Report With Dummy Variables

In [9]:
```
df_pca_exp_var
```

Out[9]:

	Features	PCA_Exp_Var	Cummulative Exp Var
0	Sales/Revenues	0.0936	0.0936
1	Gross Margin	0.0737	0.1673
2	EBITDA	0.0707	0.2381
3	EBITDA Margin	0.0517	0.2897
4	Net Income Before Extras	0.0495	0.3392
5	Total Debt	0.0481	0.3873
6	Net Debt	0.0372	0.4245
7	LT Debt	0.0298	0.4543
8	ST Debt	0.0288	0.4831
9	Cash	0.0282	0.5113
10	Free Cash Flow	0.0272	0.5385

In [10]:
```
plotX = df_pca_exp_var.iloc[:, 0]
plotY1 = df_pca_exp_var.iloc[:, 1]
plotY2 = df_pca_exp_var.iloc[:, 2]
plt.xticks(rotation=90)
plt.plot(plotX, plotY1)
plt.plot(plotX, plotY2)
plt.legend(['PCA_Exp_Var', 'Cummulative Exp Var'])
plt.tick_params(axis='x', which='major', labelsize=8)
plt.tight_layout()
```



1.1 Logistic Regression

Target Vaiable: InvGrd with Duummy Variables

In [11]:
```
## Fit the Model
logReg_model=LogisticRegression(solver='lbfgs')
logReg_model.fit(X_train,y_train)
### Predict
y_pred_train=logReg_model.predict(X_train)
y_pred_test=logReg_model.predict(X_test)
```

In [12]:
```
print("Accuracy Score of Logistic Regression Model with dummy variables on Train Set",lo
print("Accuracy Score of Logistic Regression Model with dummy variables on Test Set",log
print("ROC_AUC of Logistic Regression Model with dummy variables on Train Set",roc_auc_s
print("ROC_AUC  of Logistic Regression Model with dummy variables on Test Set",roc_auc_s
```

```
Accuracy Score of Logistic Regression Model with dummy variables on Train Set 1.0
Accuracy Score of Logistic Regression Model with dummy variables on Test Set 1.0
ROC_AUC of Logistic Regression Model with dummy variables on Train Set 1.0
ROC_AUC  of Logistic Regression Model with dummy variables on Test Set 1.0
```

As we noticed creating the dummy variables is boosting the model accuracy. In the following code we are going to remove "Rating" dummy variables and run the logistic regression model again and see what happens to the result.

In [13]:
```
list_to_drop=['InvGrd', 'Rating', 'A1', 'A2', 'A3', 'Aa2', 'Aa3', 'Aaa',
       'B1', 'B2', 'B3', 'Ba1', 'Ba2', 'Ba3', 'Baa1', 'Baa2', 'Baa3', 'Caa1']
```

In [14]:
```
X=scale(df_credit_dummies.drop(list_to_drop,axis=1).values)
y=df_credit_dummies["InvGrd"].values
### Train and Test
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.25,random_state=seed)
```

In [15]:
```
del y_pred_train , y_pred_test
```

PCA without Dummy Variables

In [16]:
```
# Create PCA instance: model
pca_model = PCA()
### Fit the Features value to PCA
pca_model.fit_transform(X)
```

Out[16]:
```
array([[-0.15189997,  0.0235405 , -0.06845795, ..., -0.00784368,
        -0.00442878, -0.00160618],
       [-0.14272847,  0.03249937, -0.01855342, ..., -0.00370066,
        -0.00426299, -0.00279038],
       [-0.13566313,  0.02783463,  0.00923416, ..., -0.00908331,
        -0.00279016, -0.00242822],
       ...,
       [-0.13568104, -0.43058978, -0.44130577, ...,  0.02968121,
        -0.00582438,  0.00059085],
       [-0.0733207 , -0.4424719 , -0.4753796 , ..., -0.00732613,
        -0.00338393, -0.00238864],
       [-0.18756961, -0.4270099 , -0.50309818, ..., -0.0221842 ,
        -0.00134203, -0.00167871]])
```

In [17]:
```
X_features=list(df_credit_dummies.drop(list_to_drop,axis=1).columns)
```

In [18]:
```
df_pca_exp_var=pd.DataFrame({"Features":X_features,
              "PCA_Exp_Var":pca_model.explained_variance_ratio_}).sort_values("PCA_Exp_\
df_pca_exp_var["Cummulative Exp Var"]=df_pca_exp_var["PCA_Exp_Var"].cumsum()
```

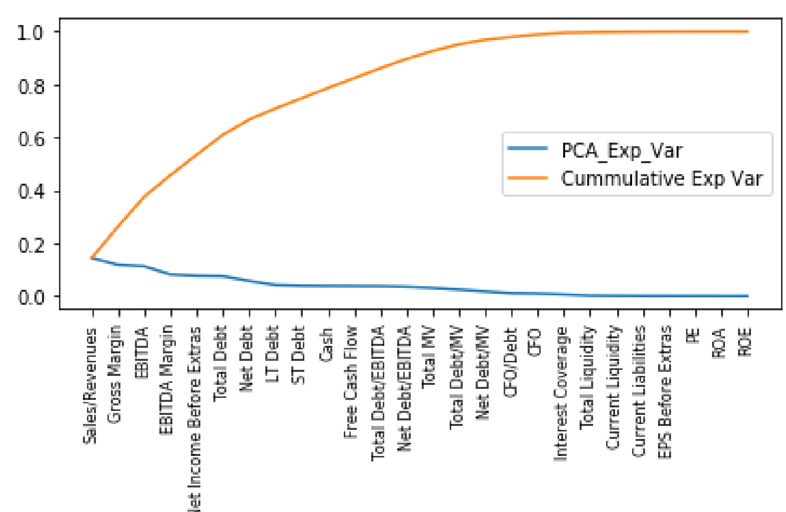
PCA Report Without Dummy Variables

In [19]:
```
df_pca_exp_var
```

Out[19]:

	Features	PCA_Exp_Var	Cummulative Exp Var
0	Sales/Revenues	0.1443	0.1443
1	Gross Margin	0.1185	0.2628
2	EBITDA	0.1126	0.3754
3	EBITDA Margin	0.0819	0.4573
4	Net Income Before Extras	0.0769	0.5342
5	Total Debt	0.0755	0.6097
6	Net Debt	0.0575	0.6672
7	LT Debt	0.0420	0.7092
8	ST Debt	0.0390	0.7482
9	Cash	0.0382	0.7864
10	Free Cash Flow	0.0377	0.8241

In [20]:
```
plotX = df_pca_exp_var.iloc[:, 0]
plotY1 = df_pca_exp_var.iloc[:, 1]
plotY2 = df_pca_exp_var.iloc[:, 2]
plt.xticks(rotation=90)
plt.plot(plotX, plotY1)
plt.plot(plotX, plotY2)
plt.legend(['PCA_Exp_Var', 'Cummulative Exp Var'])
plt.tick_params(axis='x', which='major', labelsize=8)
plt.tight_layout()
```



1.2 Logistic Regression

Target Vaiable: InvGrd without Duummy Variables

In [21]:
```
## Fit the Model
logReg_model=LogisticRegression(solver='lbfgs')
logReg_model.fit(X_train,y_train)
### Predict
y_pred_train=logReg_model.predict(X_train)
y_pred_test=logReg_model.predict(X_test)
```

In [22]:
```
print("Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Train Set"
print("Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Test Set",
print("ROC_AUC of Logistic Regression Model WITHOUT dummy variables on Train Set",roc_au
print("ROC_AUC  of Logistic Regression Model WITHOUT dummy variables on Test Set",roc_au
```

```
Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Train Set 0.
7717647058823529
Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Test Set 0.7
529411764705882
ROC_AUC of Logistic Regression Model WITHOUT dummy variables on Train Set 0.5353135
034645935
ROC_AUC  of Logistic Regression Model WITHOUT dummy variables on Test Set 0.5291506
017058067
```

In [23]:
```
df_models_summary=pd.DataFrame({"Model":["Logistic Regression"],"Accuracy Train":[logReg
             "Accuracy Test":[logReg_model.score(X_test,y_test)],
             "ROC Train":roc_auc_score(y_train,y_pred_train),
            "ROC Test":roc_auc_score(y_test,y_pred_test)})
```

In [24]:
```
df_models_summary
```

Out[24]:

	Model	Accuracy Train	Accuracy Test	ROC Train	ROC Test
0	Logistic Regression	0.7718	0.7529	0.5353	0.5292

Classification Report on Test Set

In [25]:
```
print(classification_report(y_test,y_pred_test))
```

```
              precision    recall  f1-score   support

           0       0.62      0.07      0.13       108
           1       0.76      0.98      0.86       317

    accuracy                           0.75       425
   macro avg       0.69      0.53      0.49       425
weighted avg       0.72      0.75      0.67       425
```

In [26]:
```
import pandas as pd
y_actu = pd.Series(y_test, name='Actual')
y_pred = pd.Series(y_pred_test, name='Predicted')
df_confusion = pd.crosstab(y_actu, y_pred)
```

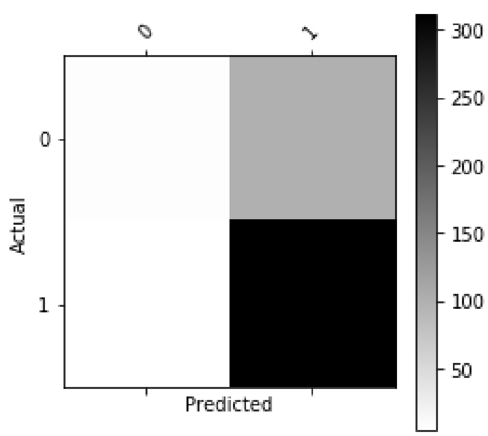
In [27]:
```
df_confusion
```

Out[27]:

Predicted	0	1
Actual		
0	8	100
1	5	312

In [28]:
```
import matplotlib.pyplot as plt
def plot_confusion_matrix(df_confusion, title='Confusion matrix', cmap=plt.cm.gray_r):
    plt.matshow(df_confusion, cmap=cmap) # imshow
    #plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(df_confusion.columns))
    plt.xticks(tick_marks, df_confusion.columns, rotation=45)
    plt.yticks(tick_marks, df_confusion.index)
    #plt.tight_layout()
    plt.ylabel(df_confusion.index.name)
    plt.xlabel(df_confusion.columns.name)

plot_confusion_matrix(df_confusion)
```



2. Random Forest with 10 Cross Validation without dummy variables

Target Vaiable: InvGrd

In [29]:
```
del y_pred_train , y_pred_test , y_pred
```

In [30]:
```
### Random Forest Parameters
prameters_for_rfc={'n_estimators': [100,200,300,400,500],
          'criterion':['gini','entropy']}
```

In [31]:
```
### Initiate Random Forest Model With Max Depth=2
random_forest_classsifier_model=RandomForestClassifier(random_state=seed,max_depth=3)

### Initiate Random Forest Model with 10 Fold Cross Validation
random_forest_classsifier_model_gridcv=GridSearchCV(estimator=random_forest_classsifier_
                                                     cv=10,
                                                    scoring='accuracy')

### Fit Random Forest Model with Cross Validation
random_forest_classsifier_model_gridcv.fit(X_train,y_train)

### Get the Best Score of the cross validate model
random_forest_classsifier_model_gridcv.best_score_
```

Out[31]:
```
0.7819607843137255
```

In [32]:
```
print("Best Random Forest Model is the one with the following Parameters",random_forest_
```

```
Best Random Forest Model is the one with the following Parameters {'criterion': 'gini',
'n_estimators': 100}
```

Selecting Best Random Forest Model

In [33]:
```
random_forest_classsifier_model_with_best_param=random_forest_classsifier_model_gridcv.b
random_forest_classsifier_model_gridcv.best_estimator_
```

Out[33]:
```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                       max_depth=3, 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=100,
                       n_jobs=None, oob_score=False, random_state=42, verbose=0,
                       warm_start=False)
```

In Sample Accuracy (Train)

In [34]:
```
### Fit to the best Model
random_forest_classsifier_model_with_best_param.fit(X_train,y_train)
### Training set prediction
y_pred_train=random_forest_classsifier_model_with_best_param.predict(X_train)
### Training set ROC Score and Accuracy Score
print("ROC AUC Sccore of the best RF model on Train Set",roc_auc_score(y_train,y_pred_tr
print("Accuracy score of best RF on Train",accuracy_score(y_train,y_pred_train))
```

```
ROC AUC Sccore of the best RF model on Train Set 0.5925046476254859
Accuracy score of best RF on Train 0.8023529411764706
```

Out Sample Accuracy (Test)

In [35]:
```
### Test set ROC Score and Accuracy Score
y_pred_test=random_forest_classsifier_model_with_best_param.predict(X_test)
print("ROC AUC Sccore of the best RF model on Test Set",roc_auc_score(y_test,y_pred_test
print("Accuracy score of best RF on Test",accuracy_score(y_test,y_pred_test))
```

```
ROC AUC Sccore of the best RF model on Test Set 0.5693422128753359
Accuracy score of best RF on Test 0.7764705882352941
```

In [36]:
```
pd.DataFrame({"Model":["Random Forest"],"Accuracy Train":[accuracy_score(y_train,y_pred_
             "Accuracy Test":[accuracy_score(y_test,y_pred_test)],
             "ROC Train":roc_auc_score(y_train,y_pred_train),
            "ROC Test":roc_auc_score(y_test,y_pred_test)})
```

Out[36]:

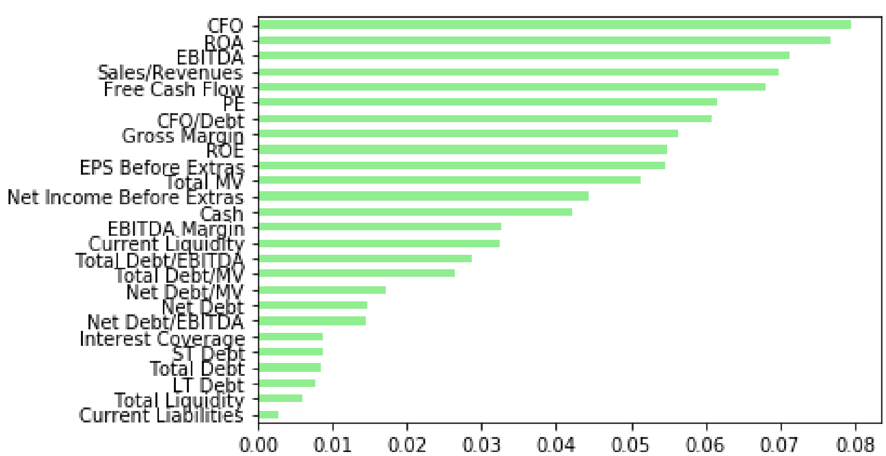
	Model	Accuracy Train	Accuracy Test	ROC Train	ROC Test
0	Random Forest	0.8024	0.7765	0.5925	0.5693

In [37]:
```
df_models_summary=pd.concat([df_models_summary,pd.DataFrame(
    {"Model":["Random Forest"],"Accuracy Train":[accuracy_score(y_train,y_pred_train)],
             "Accuracy Test":[accuracy_score(y_test,y_pred_test)],
             "ROC Train":roc_auc_score(y_train,y_pred_train),
            "ROC Test":roc_auc_score(y_test,y_pred_test)})])
```

In [38]:
```
random_forest_classsifier_model_with_best_param.feature_importances_
```

Out[38]:
```
array([0.06977861, 0.05635957, 0.07123801, 0.03276124, 0.04432367,
       0.00851944, 0.01474779, 0.00761444, 0.008769  , 0.04213864,
       0.06794936, 0.02860935, 0.01448993, 0.05124046, 0.02644558,
       0.01713333, 0.06076943, 0.07945242, 0.00880084, 0.00610081,
       0.03229257, 0.00272128, 0.05465327, 0.06158875, 0.07671441,
       0.0547878 ])
```

In [39]:
```
importances_rf=pd.Series(random_forest_classsifier_model_with_best_param.feature_importa
          index = X_features)
# Sort importances_rf
sorted_importances_rf = importances_rf.sort_values()
# Make a horizontal bar plot
sorted_importances_rf.plot(kind='barh', color='lightgreen')
plt.show()
```



3. SVM

Target Vaiable: InvGrd

1. kernel='linear'
2. kernel='rbf

In [40]:
```
del y_pred_train , y_pred_test
```

In [41]:
```
### Linear SVM
svm_linear_classification=svm.SVC(C=1,gamma='scale',kernel='linear')
svm_linear_classification.fit(X_train,y_train)

### Linear SVM Prediction
y_pred_train=svm_linear_classification.predict(X_train)
y_pred_test=svm_linear_classification.predict(X_test)
```

In [42]:
```
print("Accuracy Score of Linear SVM Model WITHOUT dummy variables on Train Set",
      svm_linear_classification.score(X_train,y_train))

print("Accuracy Score of Linear SVM Model WITHOUT dummy variables on Test Set",
      svm_linear_classification.score(X_test,y_test))

print("ROC_AUC of Linear SVM Model WITHOUT dummy variables on Train Set",
      roc_auc_score(y_train,y_pred_train))

print("ROC_AUC  of Linear SVM Model WITHOUT dummy variables on Test Set",
      roc_auc_score(y_test,y_pred_test))
```

```
Accuracy Score of Linear SVM Model WITHOUT dummy variables on Train Set 0.7686274509803
922
Accuracy Score of Linear SVM Model WITHOUT dummy variables on Test Set 0.74823529411764
71
ROC_AUC of Linear SVM Model WITHOUT dummy variables on Train Set 0.5175173229677201
ROC_AUC  of Linear SVM Model WITHOUT dummy variables on Test Set 0.5076819721930131
```

In [43]:
```
### Models Summary
df_models_summary=pd.concat([df_models_summary,pd.DataFrame({"Model":["SVM Linear"],"Acc
             "Accuracy Test":[svm_linear_classification.score(X_test,y_test)],
             "ROC Train":roc_auc_score(y_train,y_pred_train),
            "ROC Test":roc_auc_score(y_test,y_pred_test)})])
```

In [44]:
```
del y_pred_train , y_pred_test
```

In [45]:
```
### RBF SVM
svm_rfb_classification=svm.SVC(C=2,gamma='scale',kernel='rbf')
svm_rfb_classification.fit(X_train,y_train)

### RBF SVM prediction
y_pred_train=svm_rfb_classification.predict(X_train)
y_pred_test=svm_rfb_classification.predict(X_test)
```

In [46]:
```
print("Accuracy Score of RBF SVM Model WITHOUT dummy variables on Train Set",
      svm_rfb_classification.score(X_train,y_train))

print("Accuracy Score of RBF SVM Model WITHOUT dummy variables on Test Set",
      svm_rfb_classification.score(X_test,y_test))

print("ROC_AUC of RBF SVM Model WITHOUT dummy variables on Train Set",
      roc_auc_score(y_train,y_pred_train))

print("ROC_AUC of RBF SVM Model WITHOUT dummy variables on Test Set",
      roc_auc_score(y_test,y_pred_test))
```

```
Accuracy Score of RBF SVM Model WITHOUT dummy variables on Train Set 0.8258823529411765
Accuracy Score of RBF SVM Model WITHOUT dummy variables on Test Set 0.7623529411764706
ROC_AUC of RBF SVM Model WITHOUT dummy variables on Train Set 0.6439327361838769
ROC_AUC of RBF SVM Model WITHOUT dummy variables on Test Set 0.5629308330412431
```

In [47]:
```
df_models_summary=pd.concat([df_models_summary,pd.DataFrame({"Model":["SVM RFB"],
                                            "Accuracy Train":[svm_rfb_classification.scor
            "Accuracy Test":[svm_rfb_classification.score(X_test,y_test)],
            "ROC Train":roc_auc_score(y_train,y_pred_train),
           "ROC Test":roc_auc_score(y_test,y_pred_test)})])
```

Ensumbling for InvGrd

4 Models were fitted for InvGrd as Target Variable

In [48]:
```
### Linear SVM
svm_linear_classification=svm.SVC(C=1,gamma='scale',kernel='linear')
### RBF SVM
svm_rfb_classification=svm.SVC(C=2,gamma='scale',kernel='rbf')
## Logistic Regression
logReg_model=LogisticRegression(solver='lbfgs')

### Define a list called Classifier that contains the tuples of Instantiatd models
classifiers=[("Logistic Regression", logReg_model),
            ('SVM RBF', svm_rfb_classification),
            ("SVM Linear",svm_linear_classification),
            ("Decision Tree Classifier",random_forest_classsifier_model_gridcv.best_esti
```

In [49]:
```
### Iterate over the difined list of tuple containing the classifiers
for clf_nam, clf in classifiers:
    ### Fit clt to the traning set
    clf.fit(X_train,y_train)
    ### Predict test
    y_pred_test=clf.predict(X_test)
    ### Evaluate the accuracy of the clf on the test set
    print((clf_nam,accuracy_score(y_test,y_pred_test)))
```

```
('Logistic Regression', 0.7529411764705882)
('SVM RBF', 0.7623529411764706)
('SVM Linear', 0.7482352941176471)
('Decision Tree Classifier', 0.7764705882352941)
```

In [50]:
```
### Instatitate a VotingClassifier 'vc'
vc=VotingClassifier(estimators=classifiers)
### Fit the VotingClassifier
vc.fit(X_train,y_train)
y_pred_train=vc.predict(X_train)
y_pred_test=vc.predict(X_test)
print("Accuracy of Voting Classifier Ensumbled Train", vc.score(X_train,y_train))
print("Accuracy of Voting Classifier Ensumbled Test", vc.score(X_test,y_test))
```

```
Accuracy of Voting Classifier Ensumbled Train 0.8023529411764706
Accuracy of Voting Classifier Ensumbled Test 0.7670588235294118
```

In [51]:
```
df_models_summary=pd.concat([df_models_summary,pd.DataFrame({"Model":["Voting Classifier
                                            "Accuracy Train":[vc.score(X_train,y_train)],
             "Accuracy Test":[vc.score(X_test,y_test)],
             "ROC Train":[roc_auc_score(y_train,y_pred_train)],
            "ROC Test":[roc_auc_score(y_test,y_pred_test)]})])
```

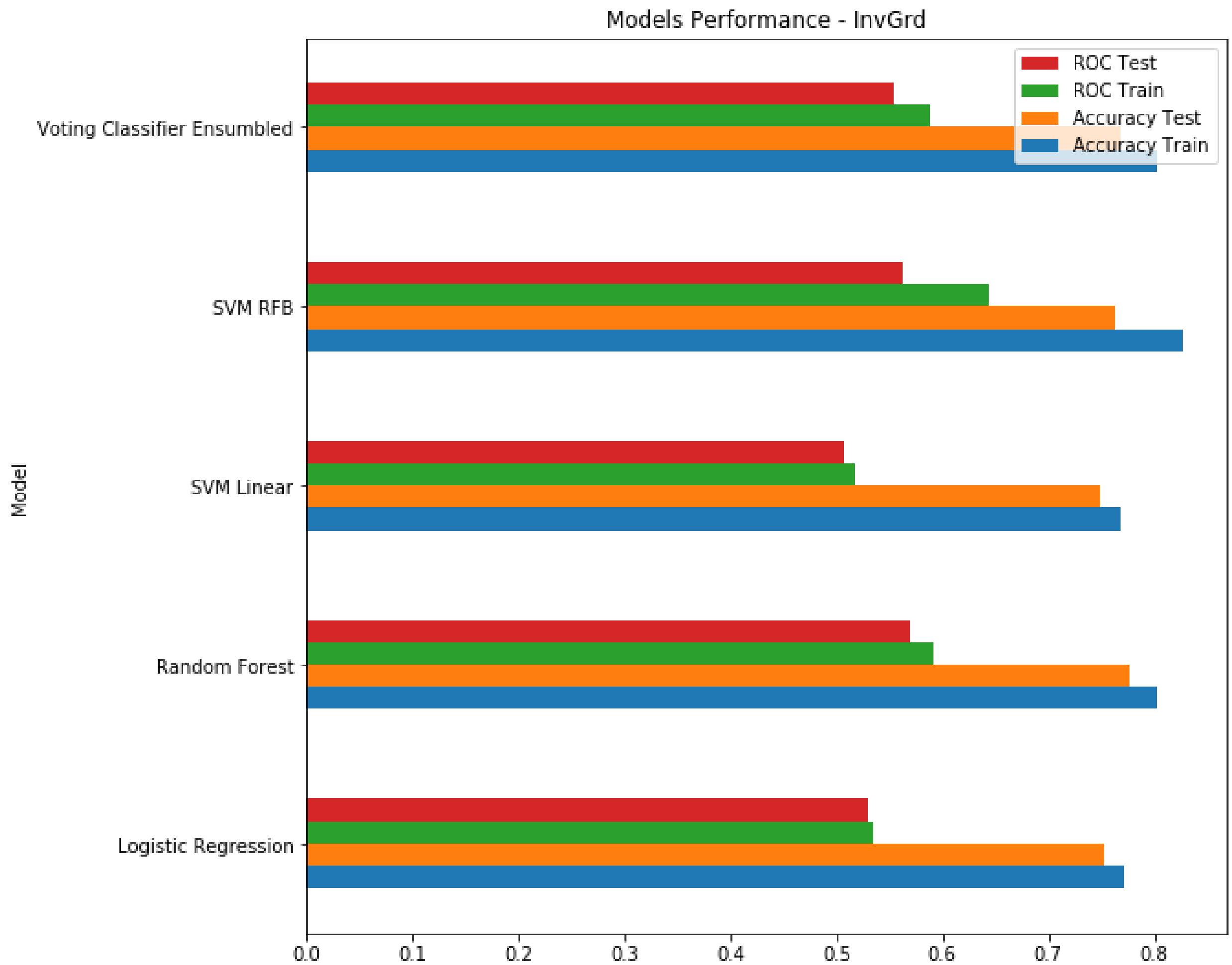
In [52]:
```
df_models_summary
```

Out[52]:

	Model	Accuracy Train	Accuracy Test	ROC Train	ROC Test
0	Logistic Regression	0.7718	0.7529	0.5353	0.5292
0	Random Forest	0.8024	0.7765	0.5925	0.5693
0	SVM Linear	0.7686	0.7482	0.5175	0.5077
0	SVM RFB	0.8259	0.7624	0.6439	0.5629
0	Voting Classifier Ensumbled	0.8024	0.7671	0.5880	0.5539

In [53]:
```
df_models_summary.plot("Model",kind='barh',title="Models Performance - InvGrd",figsize=(
```

Out[53]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x162e45c5978>
```



Conclusion

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

1 Logistic Regression

Target Vaiable: Rating

In [54]:

```
del X_train,X_test,y_train, y_test , y_pred_test, y_pred_train , logReg_model
```

In [55]:

```
y=df_credit["Rating"].values
### Train and Test
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.25,random_state=seed)
```

In [56]:

```
## Fit the Model
logReg_model=LogisticRegression(solver='newton-cg',multi_class ='multinomial')
logReg_model.fit(X_train,y_train)
### Predict
y_pred_train=logReg_model.predict(X_train)
y_pred_test=logReg_model.predict(X_test)
```

In [57]:

```
print("Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Train Set",
print("Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Test Set",
```

```
Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Train Set 0.
2627450980392157
Accuracy Score of Logistic Regression Model WITHOUT dummy variables on Test Set 0.2
023529411764706
```

In [58]:

```
#logReg_model.score(X_test,y_test)
df_models_summary_rating=pd.DataFrame({"Model":"Logistic Regression",
              "Train Accuracy Score":[logReg_model.score(X_train,y_train)],
             "Test Accuracy Score":[logReg_model.score(X_train,y_train)]})
```

2 Random Forest

Target Vaiable: Rating

In [59]:

```
del  y_pred_test, y_pred_train
```

In [60]:
```
del random_forest_classsifier_model_gridcv, random_forest_classsifier_model
```

In [61]:
```
### Random Forest Parameters
prameters_for_rfc={'n_estimators': [100,200,300,400,500],
          'criterion':['gini','entropy'],
                  'max_depth':[1,2,3,4,5,6,7,8,9,10,11,12,13,14]}
```

In [62]:
```
### Initiate Random Forest Model With Max Depth=2
random_forest_classsifier_model=RandomForestClassifier(random_state=seed)

### Initiate Random Forest Model with 10 Fold Cross Validation
random_forest_classsifier_model_gridcv=GridSearchCV(estimator=random_forest_classsifier_
                                                cv=2,iid=False,
                                               scoring='accuracy')

### Fit Random Forest Model with Cross Validation
random_forest_classsifier_model_gridcv.fit(X_train,y_train)

### Get the Best Score of the cross validate model
random_forest_classsifier_model_gridcv.best_score_
```

Out[62]:
```
0.48464144926252384
```

In [63]:
```
print("Best Random Forest Model is the one with the following Parameters\n",
      random_forest_classsifier_model_gridcv.best_params_)
```

```
Best Random Forest Model is the one with the following Parameters
 {'criterion': 'entropy', 'max_depth': 14, 'n_estimators': 500}
```

Selecting best Random Forest model

In [64]:
```
random_forest_classsifier_model_with_best_param=random_forest_classsifier_model_gridcv.b
random_forest_classsifier_model_gridcv.best_estimator_
```

Out[64]:
```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
                       max_depth=14, 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=500,
                       n_jobs=None, oob_score=False, random_state=42, verbose=0,
                       warm_start=False)
```

In Sample Accuracy (Train)

In [65]:
```
### Fit to the best Model
random_forest_classsifier_model_with_best_param.fit(X_train,y_train)
### Training set prediction
y_pred_train=random_forest_classsifier_model_with_best_param.predict(X_train)
### Training set ROC Score
print("Accuracy Sccore of the best model on Training Set",
      random_forest_classsifier_model_with_best_param.score(X_train,y_train))
```

```
Accuracy Sccore of the best model on Training Set 1.0
```

Out Sample Accuracy (Test)

In [66]:
```
y_pred_test=random_forest_classsifier_model_with_best_param.predict(X_test)
print("Accuracy Score of the best model on Test Set",
      random_forest_classsifier_model_with_best_param.score(X_test,y_test))
```

```
Accuracy Score of the best model on Test Set 0.6447058823529411
```

In [67]:
```
df_models_summary_rating=pd.concat([df_models_summary_rating,pd.DataFrame({"Model":"Ranc
                        "Train Accuracy Score":[random_forest_classsifier_model_with_best_param.sc
                      "Test Accuracy Score":[random_forest_classsifier_model_with_best_param.scor
```

Are we overfitting?

It seems we may be overfitting the model by selecting high number of max depth (more than 10) for the trees and the big diffrence between in sample accuracy vs out of sample accuracy. So we are investiating that here below

Random Models Fitted Preformance

In [68]:
```
df_models_summary_rating_rf=pd.merge(pd.DataFrame(random_forest_classsifier_model_gridcv
         pd.DataFrame({"mean_test_score":(list(
    random_forest_classsifier_model_gridcv.cv_results_['mean_test_score']))}).reset_inde
         left_on="index",right_on="index",how="left").drop("index",axis=1)
df_models_summary_rating_rf["Model"]="Random Forest"
```

In [69]:
```
df_models_summary_rating_rf.head(2)
```

Out[69]:

	criterion	max_depth	n_estimators	mean_test_score	Model
0	gini	1	100	0.1945	Random Forest
1	gini	1	200	0.1961	Random Forest

In [70]:
```
list_of_train_score=[]
for cir, depth, n_tree in zip(
    list(df_models_summary_rating_rf["criterion"]),
    list(df_models_summary_rating_rf["max_depth"]),
   list(df_models_summary_rating_rf["n_estimators"])):
    dt=RandomForestClassifier(random_state=seed,criterion=cir,
                              max_depth=depth,n_estimators=n_tree,)
    dt.fit(X_train,y_train)
    list_of_train_score.append(dt.score(X_train,y_train))
```

In [71]:
```
df_models_summary_rating_rf["Train Accuracy Score"]=list_of_train_score
```

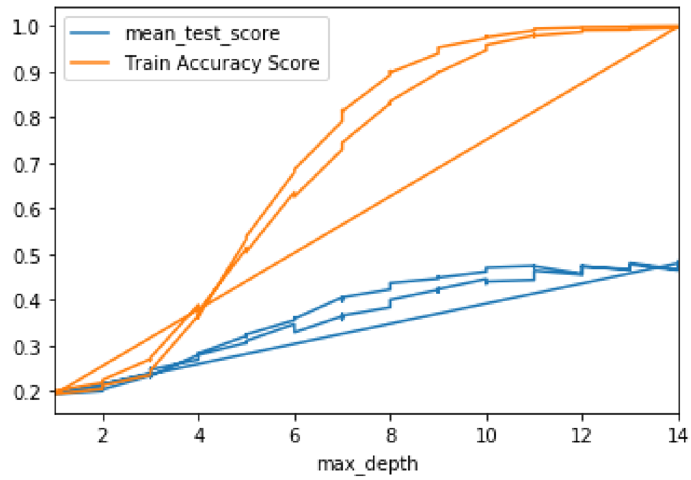
In [72]:
```
df_models_summary_rating_rf.sort_values(["mean_test_score"],ascending=False).head()
```

Out[72]:

	criterion	max_depth	n_estimators	mean_test_score	Model	Train Accuracy Score
139	entropy	14	500	0.4846	Random Forest	1.0000
134	entropy	13	500	0.4807	Random Forest	0.9992
69	gini	14	500	0.4799	Random Forest	0.9984
64	gini	13	500	0.4776	Random Forest	0.9929
133	entropy	13	400	0.4768	Random Forest	0.9992

In [73]:
```
df_models_summary_rating_rf.plot(y=["mean_test_score","Train Accuracy Score"],x="max_dep
```

Out[73]: <matplotlib.axes._subplots.AxesSubplot at 0x162e30e0cf8>



Our analysis shows its the nature of the data that requiers lagre number of max depth for improvment and we are not overfitting as we the accurcy of the train and test are increasing together as the number of max depth are growing.

SVM

Target Vaiable: Rating

In [74]:
```
del y_pred_train , y_pred_test
```

In [75]:
```
### RBF SVM
svm_classification=svm.SVC(gamma='auto')
```

In [76]:
```
### RBF Parameters
prameters_for_SVM={'C':range(1,10),
          'kernel':['rbf','linear']}
### Fit the model
svm_classification_gridcv=GridSearchCV(estimator=svm_classification,param_grid=prameters
                                                cv=2,
                                               scoring='accuracy')
svm_classification_gridcv.fit(X_train,y_train)
print("Best SVM Model is",svm_classification_gridcv.best_estimator_)
```

```
Best SVM Model is SVC(C=9, cache_size=200, class_weight=None, coef0=0.0,
    decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
    max_iter=-1, probability=False, random_state=None, shrinking=True,
    tol=0.001, verbose=False)
```

In [77]:
```
df_models_summary_rating=pd.concat([df_models_summary_rating,pd.DataFrame({"Model":"SVM"
              "Train Accuracy Score":[svm_classification_gridcv.score(X_train,y_train)],
             "Test Accuracy Score":[svm_classification_gridcv.score(X_test,y_test)]})])
```

In [78]:
```
df_models_summary_rating
```

Out[78]:

	Model	Train Accuracy Score	Test Accuracy Score
0	Logistic Regression	0.2627	0.2627
0	Random Forest	1.0000	0.6447
0	SVM	0.4235	0.2800

Ensumbling for Rating

3 Models were fitted for Rating as Target Variable

In [79]:
```
### Define a list called Classifier that contains the tuples of Instantiatd models
logReg_model=LogisticRegression(solver='newton-cg',multi_class ='multinomial')
classifiers=[("Logistic Regression", logReg_model),
            ("SVM Classification",svm_classification_gridcv.best_estimator_),
            ("Decision Tree Classifier",random_forest_classsifier_model_gridcv.best_esti
```

In [80]:
```
### Iterate over the difined list of tuple containing the classifiers
for clf_nam, clf in classifiers:
    ### Fit clt to the traning set
    clf.fit(X_train,y_train)
    ### Predict test
    y_pred_test=clf.predict(X_test)
    ### Evaluate the accuracy of the clf on the test set
    print((clf_nam,accuracy_score(y_test,y_pred_test)))
```

```
('Logistic Regression', 0.2023529411764706)
('SVM Classification', 0.28)
('Decision Tree Classifier', 0.6447058823529411)
```

In [81]:
```
### Instatitate a VotingClassifier 'vc'
vc=VotingClassifier(estimators=classifiers)
### Fit the VotingClassifier
vc.fit(X_train,y_train)
y_pred_train=vc.predict(X_train)
y_pred_test=vc.predict(X_test)
print("Accuracy of Voting Classifier Ensumbled Rating Train", vc.score(X_train,y_train))
print("Accuracy of Voting Classifier Ensumbled Rating Test", vc.score(X_test,y_test))
```

```
Accuracy of Voting Classifier Ensumbled Rating Train 0.6603921568627451
Accuracy of Voting Classifier Ensumbled Rating Test 0.4211764705882353
```

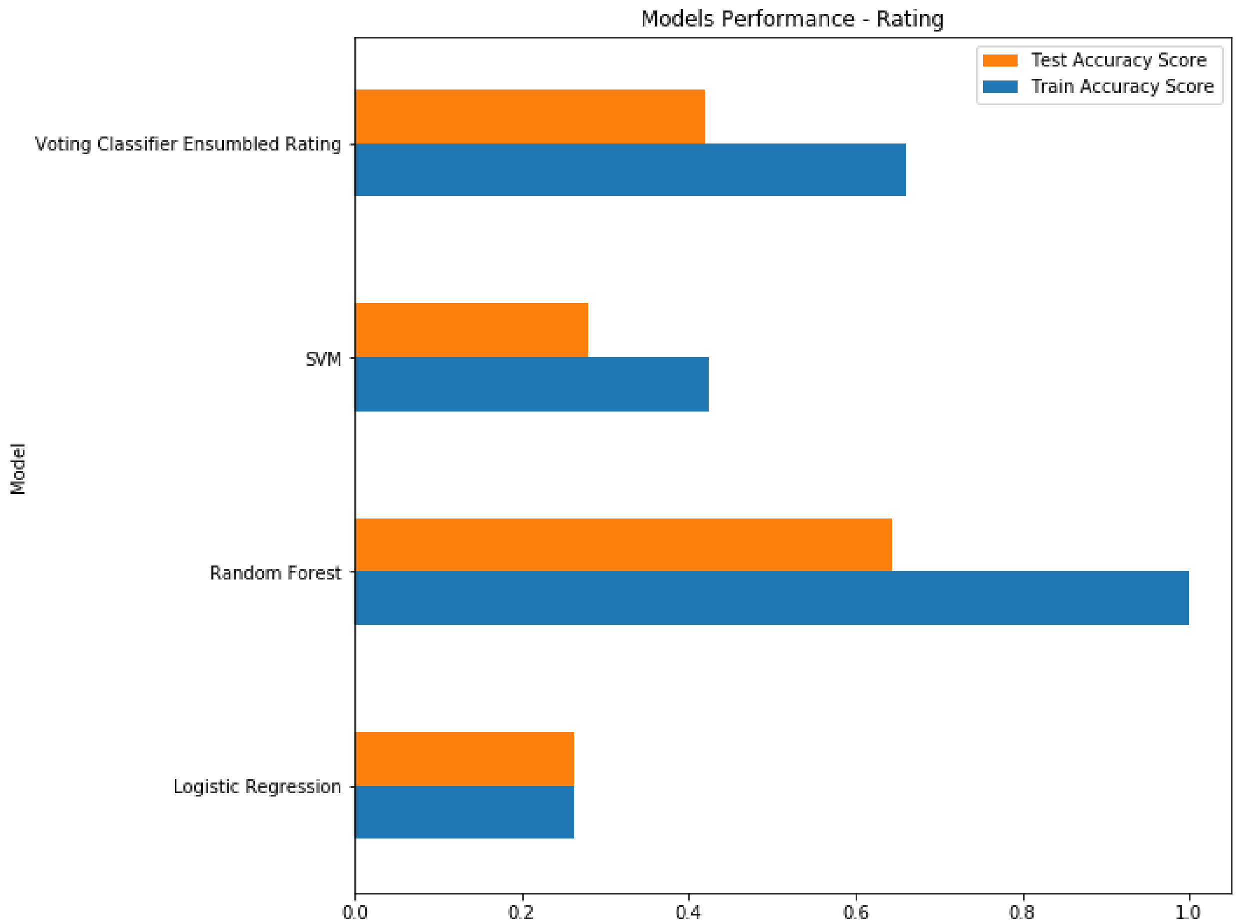
In [86]:
```
df_models_summary_rating=pd.concat([df_models_summary_rating,pd.DataFrame({"Model":["Vot
                                            "Train Accuracy Score":[vc.score(X_train,y_tr
             "Test Accuracy Score":[vc.score(X_test,y_test)]})],sort=False)
df_models_summary_rating
```

Out[86]:

	Model	Train Accuracy Score	Test Accuracy Score
0	Logistic Regression	0.2627	0.2627
0	Random Forest	1.0000	0.6447
0	SVM	0.4235	0.2800
0	Voting Classifier Ensumbled Rating	0.6604	0.4212

In [87]:
```
df_models_summary_rating.plot("Model",kind='barh',title="Models Performance - Rating",fi
```

Out[87]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x162f2db2438>
```



In [ ]:

In [ ]:

In [ ]: