In [153]:

```
import pandas as pd
import seaborn as sns

from pandas.core.dtypes.common import is_numeric_dtype
import matplotlib.pyplot as plt
```

In [154]:

```
#import dataset from github
bank_data = 'https://raw.githubusercontent.com/rashakil-ds/Public-Datasets/mai
```

In [155]:

```
df = pd.read_csv(bank_data)
```

In [156]:

```
#showing first 5 rows
df.head()
```

Out[156]:

	ID	Customer_ID	Month	Name	Age	SSN	Occupation	Annual_Income	Monthly
0	0x160a	CUS_0xd40	September	Aaron Maashoh	23	821-00-0265	Scientist	19114.12	
1	0x160b	CUS_0xd40	October	Aaron Maashoh	24	821-00-0265	Scientist	19114.12	
2	0x160c	CUS_0xd40	November	Aaron Maashoh	24	821-00-0265	Scientist	19114.12	
3	0x160d	CUS_0xd40	December	Aaron Maashoh	24_	821-00-0265	Scientist	19114.12	
4	0x1616	CUS_0x21b1	September	Rick Rothackerj	28	004-07-5839	_______	34847.84	

5 rows × 27 columns

In [157]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 50000 entries, 0 to 49999
Data columns (total 27 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   ID                        50000 non-null  object 
 1   Customer_ID               50000 non-null  object 
 2   Month                     50000 non-null  object 
 3   Name                      44985 non-null  object 
 4   Age                       50000 non-null  object 
 5   SSN                       50000 non-null  object 
 6   Occupation                50000 non-null  object 
 7   Annual_Income             50000 non-null  object 
 8   Monthly_Inhand_Salary     42502 non-null  float64
 9   Num_Bank_Accounts         50000 non-null  int64  
 10  Num_Credit_Card           50000 non-null  int64  
 11  Interest_Rate             50000 non-null  int64  
 12  Num_of_Loan               50000 non-null  object 
 13  Type_of_Loan              44296 non-null  object 
 14  Delay_from_due_date       50000 non-null  int64  
 15  Num_of_Delayed_Payment    46502 non-null  object 
 16  Changed_Credit_Limit      50000 non-null  object 
 17  Num_Credit_Inquiries      48965 non-null  float64
 18  Credit_Mix                50000 non-null  object 
 19  Outstanding_Debt          50000 non-null  object 
 20  Credit_Utilization_Ratio  50000 non-null  float64
 21  Credit_History_Age        45530 non-null  object 
 22  Payment_of_Min_Amount     50000 non-null  object 
 23  Total_EMI_per_month       50000 non-null  float64
 24  Amount_invested_monthly   47729 non-null  object 
 25  Payment_Behaviour         50000 non-null  object 
 26  Monthly_Balance           49438 non-null  object 
dtypes: float64(4), int64(4), object(19)
memory usage: 10.3+ MB
```

In [158]:
```
df.describe()
```

Out[158]:

	Monthly_Inhand_Salary	Num_Bank_Accounts	Num_Credit_Card	Interest_Rate	Delay_from
count	42502.000000	50000.000000	50000.000000	50000.000000	500
mean	4182.004291	16.838260	22.921480	68.772640	
std	3174.109304	116.396848	129.314804	451.602363	
min	303.645417	-1.000000	0.000000	1.000000	
25%	1625.188333	3.000000	4.000000	8.000000	
50%	3086.305000	6.000000	5.000000	13.000000	
75%	5934.189094	7.000000	7.000000	20.000000	
max	15204.633333	1798.000000	1499.000000	5799.000000	

remove outliers

In [159]:
```
df.isnull().sum()
```

Out[159]:
```
ID                             0
Customer_ID                    0
Month                          0
Name                        5015
Age                            0
SSN                            0
Occupation                     0
Annual_Income                  0
Monthly_Inhand_Salary       7498
Num_Bank_Accounts              0
Num_Credit_Card                0
Interest_Rate                  0
Num_of_Loan                    0
Type_of_Loan                5704
Delay_from_due_date            0
Num_of_Delayed_Payment      3498
Changed_Credit_Limit           0
Num_Credit_Inquiries        1035
Credit_Mix                     0
Outstanding_Debt               0
Credit_Utilization_Ratio       0
Credit_History_Age          4470
Payment_of_Min_Amount          0
Total_EMI_per_month            0
Amount_invested_monthly     2271
Payment_Behaviour              0
Monthly_Balance              562
dtype: int64
```

In [160]:
```
df.duplicated().sum()
```

Out[160]:
```
0
```

In [161]:
```
df.columns
```

Out[161]:
```
Index(['ID', 'Customer_ID', 'Month', 'Name', 'Age', 'SSN', 'Occupation',
       'Annual_Income', 'Monthly_Inhand_Salary', 'Num_Bank_Accounts',
       'Num_Credit_Card', 'Interest_Rate', 'Num_of_Loan', 'Type_of_Loan',
       'Delay_from_due_date', 'Num_of_Delayed_Payment', 'Changed_Credit_Limi
t',
       'Num_Credit_Inquiries', 'Credit_Mix', 'Outstanding_Debt',
       'Credit_Utilization_Ratio', 'Credit_History_Age',
       'Payment_of_Min_Amount', 'Total_EMI_per_month',
       'Amount_invested_monthly', 'Payment_Behaviour', 'Monthly_Balance'],
      dtype='object')
```

In [162]:
```
df.Occupation.value_counts()
```

Out[162]:
```
Occupation
_______          3438
Lawyer           3324
Engineer         3212
Architect        3195
Mechanic         3168
Developer        3146
Accountant       3133
Media_Manager    3130
Scientist        3104
Teacher          3103
Entrepreneur     3103
Journalist       3037
Doctor           3027
Manager          3000
Musician         2947
Writer           2933
Name: count, dtype: int64
```

In [163]:
```
df.Num_Bank_Accounts.value_counts()
```

Out[163]:
```
Num_Bank_Accounts
6       6504
7       6408
8       6387
4       6100
5       6068
        ...
1247       1
1721       1
703        1
1500       1
640        1
Name: count, Length: 540, dtype: int64
```

In [164]:
```
df.Credit_Utilization_Ratio.value_counts()
```

Out[164]:
```
Credit_Utilization_Ratio
34.108530    1
35.030402    1
33.053114    1
33.811894    1
32.430559    1
            ..
29.566123    1
38.135424    1
38.226475    1
31.291849    1
29.150995    1
Name: count, Length: 50000, dtype: int64
```

In [165]:
```
df.Credit_History_Age.value_counts()
```

Out[165]:
```
Credit_History_Age
16 Years and 1 Months     254
20 Years and 1 Months     254
18 Years and 7 Months     252
19 Years and 7 Months     252
18 Years and 6 Months     250
                         ...
4 Years and 5 Months       21
0 Years and 11 Months      16
33 Years and 11 Months     15
34 Years and 0 Months      14
0 Years and 10 Months      13
Name: count, Length: 399, dtype: int64
```

Data Exploration and Preprocessing:

In [166]:
```
df.rename(columns={'Credit_Mix':'Credit Scores'} , inplace=True)
```

In [167]:
```
df.head()
```

Out[167]:

	ID	Customer_ID	Month	Name	Age	SSN	Occupation	Annual_Income	Monthly
0	0x160a	CUS_0xd40	September	Aaron Maashoh	23	821-00-0265	Scientist	19114.12	
1	0x160b	CUS_0xd40	October	Aaron Maashoh	24	821-00-0265	Scientist	19114.12	
2	0x160c	CUS_0xd40	November	Aaron Maashoh	24	821-00-0265	Scientist	19114.12	
3	0x160d	CUS_0xd40	December	Aaron Maashoh	24_	821-00-0265	Scientist	19114.12	
4	0x1616	CUS_0x21b1	September	Rick Rothackerj	28	004-07-5839	_______	34847.84	

5 rows × 27 columns

In [168]:
```
df = df.drop(['ID','Age','Customer_ID','Name','SSN','Month','Monthly_Inhand_Sa
```

In [169]:
```
df.head()
```

Out[169]:

	Occupation	Annual_Income	Num_Bank_Accounts	Num_Credit_Card	Interest_Rate	Num_of_L
0	Scientist	19114.12	3	4	3	
1	Scientist	19114.12	3	4	3	
2	Scientist	19114.12	3	4	3	
3	Scientist	19114.12	3	4	3	
4	_______	34847.84	2	4	6	

Handle any missing values

In [170]:
```
#Credit Scores this is our target variable
df['Credit Scores'].unique()
```

Out[170]:
```
array(['Good', '_', 'Standard', 'Bad'], dtype=object)
```

In [171]:
```

df['Credit Scores'] = df['Credit Scores'].replace('_', pd.NA)

```

In [172]:
```
df.isnull().sum()
```

Out[172]:
```
Occupation                   0
Annual_Income                0
Num_Bank_Accounts            0
Num_Credit_Card              0
Interest_Rate                0
Num_of_Loan                  0
Delay_from_due_date          0
Changed_Credit_Limit         0
Num_Credit_Inquiries      1035
Credit Scores             9805
Outstanding_Debt             0
Credit_Utilization_Ratio     0
Payment_of_Min_Amount        0
Total_EMI_per_month          0
Payment_Behaviour            0
Monthly_Balance            562
dtype: int64
```

In [173]:
```
df.isnull().sum()
```

Out[173]:
```
Occupation                     0
Annual_Income                  0
Num_Bank_Accounts              0
Num_Credit_Card                0
Interest_Rate                  0
Num_of_Loan                    0
Delay_from_due_date            0
Changed_Credit_Limit           0
Num_Credit_Inquiries        1035
Credit Scores               9805
Outstanding_Debt               0
Credit_Utilization_Ratio       0
Payment_of_Min_Amount          0
Total_EMI_per_month            0
Payment_Behaviour              0
Monthly_Balance              562
dtype: int64
```

In [174]:
```
df.isnull().sum()
```

Out[174]:
```
Occupation                     0
Annual_Income                  0
Num_Bank_Accounts              0
Num_Credit_Card                0
Interest_Rate                  0
Num_of_Loan                    0
Delay_from_due_date            0
Changed_Credit_Limit           0
Num_Credit_Inquiries        1035
Credit Scores               9805
Outstanding_Debt               0
Credit_Utilization_Ratio       0
Payment_of_Min_Amount          0
Total_EMI_per_month            0
Payment_Behaviour              0
Monthly_Balance              562
dtype: int64
```

In [175]:
```
df.dropna(inplace=True)
```

In [176]:
```
df[['Credit Scores']].isnull().sum()
```

Out[176]:
```
Credit Scores    0
dtype: int64
```

In [177]:
```
df.isnull().sum()
```

Out[177]:
```
Occupation                  0
Annual_Income               0
Num_Bank_Accounts           0
Num_Credit_Card             0
Interest_Rate               0
Num_of_Loan                 0
Delay_from_due_date         0
Changed_Credit_Limit        0
Num_Credit_Inquiries        0
Credit Scores               0
Outstanding_Debt            0
Credit_Utilization_Ratio    0
Payment_of_Min_Amount       0
Total_EMI_per_month         0
Payment_Behaviour           0
Monthly_Balance             0
dtype: int64
```

In [178]:
```
df.shape
```

Out[178]:
```
(38912, 16)
```

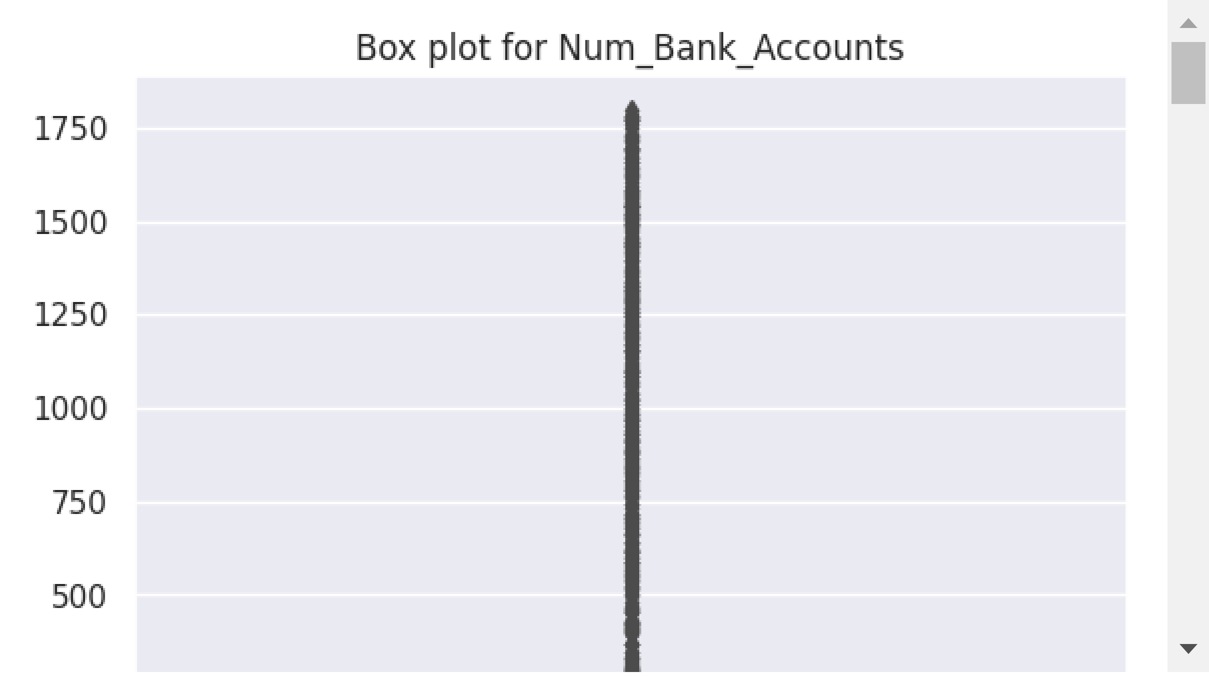
In [179]:
```
sns.set()
```

Type *Markdown* and LaTeX: α^2

outliers finding

In [180]:

```
for col in df.columns:
    if is_numeric_dtype(df[col]):
        sns.boxplot(data=df[col])
        plt.title(f'Box plot for {col}')
        plt.show()
```



In [181]:

```
df.describe()
```

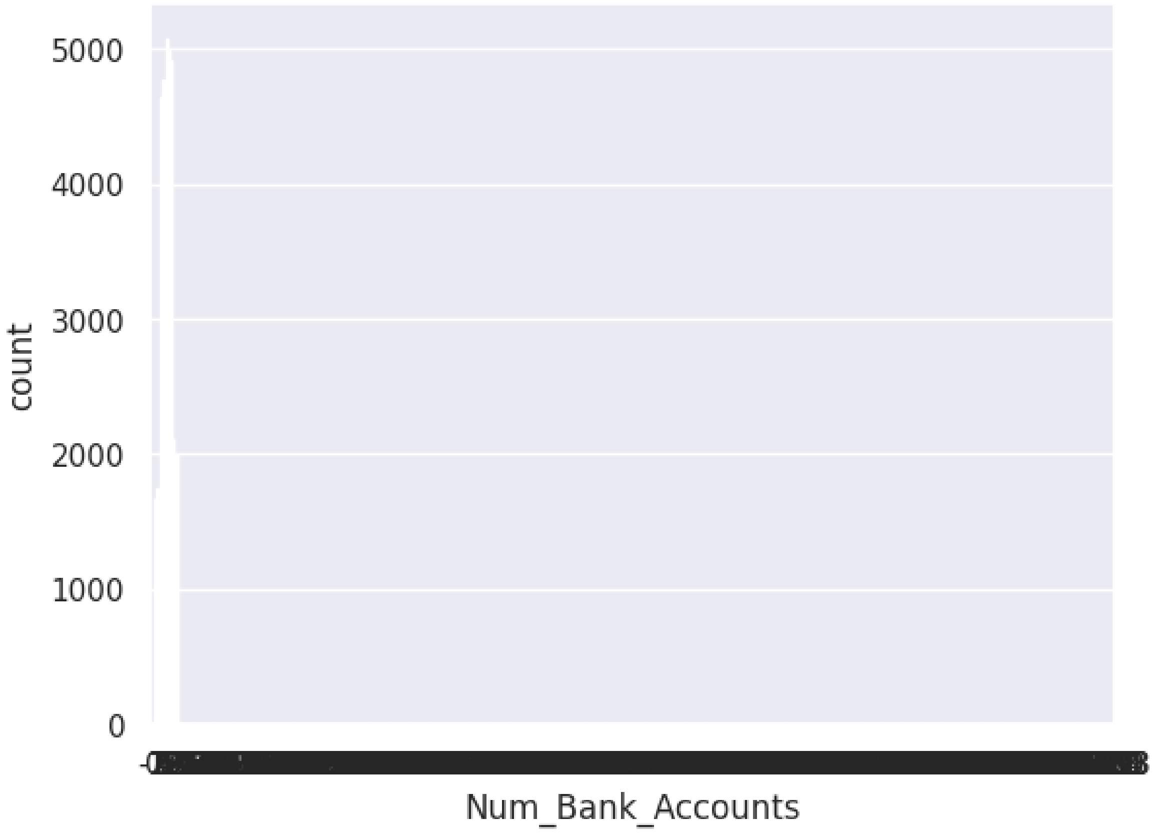
Out[181]:

	Num_Bank_Accounts	Num_Credit_Card	Interest_Rate	Delay_from_due_date	Num_Credit_
count	38912.000000	38912.000000	38912.000000	38912.000000	3891
mean	16.956389	22.653963	70.375514	20.988230	2
std	117.373909	128.218919	457.446740	14.810713	19
min	-1.000000	0.000000	1.000000	-5.000000	
25%	3.000000	4.000000	7.000000	10.000000	
50%	6.000000	5.000000	13.000000	18.000000	
75%	7.000000	7.000000	20.000000	28.000000	1
max	1798.000000	1499.000000	5799.000000	67.000000	259

**if our performance is too bad then we will remove **

In [182]:
```
sns.countplot(x = df.Num_Bank_Accounts)
```

Out[182]:
```
<Axes: xlabel='Num_Bank_Accounts', ylabel='count'>
```



- Encode

In [183]:
```
df.columns
```

Out[183]:
```
Index(['Occupation', 'Annual_Income', 'Num_Bank_Accounts', 'Num_Credit_Card',
       'Interest_Rate', 'Num_of_Loan', 'Delay_from_due_date',
       'Changed_Credit_Limit', 'Num_Credit_Inquiries', 'Credit Scores',
       'Outstanding_Debt', 'Credit_Utilization_Ratio', 'Payment_of_Min_Amoun
t',
       'Total_EMI_per_month', 'Payment_Behaviour', 'Monthly_Balance'],
      dtype='object')
```

In [184]:
```
df['Credit Scores'].unique()
```

Out[184]:
```
array(['Good', 'Standard', 'Bad'], dtype=object)
```

In [185]:

```
from sklearn.preprocessing import LabelEncoder
for i in df.columns:
    if is_numeric_dtype(df[i]):
        continue
    else:
        df[i] = LabelEncoder().fit_transform(df[i])
```

In [186]:

```
df.head()
```

Out[186]:

	Occupation	Annual_Income	Num_Bank_Accounts	Num_Credit_Card	Interest_Rate	Num_of_L
0	12	4806	3	4	3	
1	12	4806	3	4	3	
2	12	4806	3	4	3	
3	12	4806	3	4	3	
4	15	8269	2	4	6	

features selection

In [187]:

```
X = df.drop('Credit Scores' , axis =1 )
Y = df[['Credit Scores']]
```

In [188]:

```
xtrain , xtest , ytrain , ytest = train_test_split(X , Y , test_size=.2 , rand
```

In [190]:

```
from sklearn.ensemble import ExtraTreesClassifier
etc = ExtraTreesClassifier(random_state=100)
etc.fit(xtrain , ytrain)
```

Out[190]:

```
ExtraTreesClassifier(random_state=100)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [191]:

```
etc.feature_importances_
```

Out[191]:

```
array([0.0258809 , 0.03549286, 0.05967977, 0.03193272, 0.05873011,
       0.12569818, 0.17731494, 0.07074362, 0.0320701 , 0.06985645,
       0.02224756, 0.20690081, 0.02394781, 0.01877161, 0.04073258])
```

In [192]:

```
imp = pd.DataFrame(etc.feature_importances_, columns=['Gain_Score'])
cols = pd.DataFrame(df.columns, columns=['Feature_Names'])
gains = pd.concat([imp , cols] , axis = 1)
```

In [193]:

```
gains.nlargest(12,'Gain_Score')
```

Out[193]:

	Gain_Score	Feature_Names
11	0.206901	Credit_Utilization_Ratio
6	0.177315	Delay_from_due_date
5	0.125698	Num_of_Loan
7	0.070744	Changed_Credit_Limit
9	0.069856	Credit Scores
2	0.059680	Num_Bank_Accounts
4	0.058730	Interest_Rate
14	0.040733	Payment_Behaviour
1	0.035493	Annual_Income
8	0.032070	Num_Credit_Inquiries
3	0.031933	Num_Credit_Card
0	0.025881	Occupation

Occupation', 'Annual_Income', 'Num_Bank_Accounts', 'Num_Credit_Card', 'Interest_Rate', 'Num_of_Loan', 'Delay_from_due_date', 'Changed_Credit_Limit', 'Num_Credit_Inquiries', 'Credit Scores', 'Outstanding_Debt', 'Credit_Utilization_Ratio', 'Payment_of_Min_Amount', 'Total_EMI_per_month', 'Payment_Behaviour', 'Monthly_Balance'], dtype='object

In [194]:

```
df.shape
```

Out[194]:

```
(38912, 16)
```

In [195]:

```
df.columns
```

Out[195]:

```
Index(['Occupation', 'Annual_Income', 'Num_Bank_Accounts', 'Num_Credit_Card',
       'Interest_Rate', 'Num_of_Loan', 'Delay_from_due_date',
       'Changed_Credit_Limit', 'Num_Credit_Inquiries', 'Credit Scores',
       'Outstanding_Debt', 'Credit_Utilization_Ratio', 'Payment_of_Min_Amoun
t',
       'Total_EMI_per_month', 'Payment_Behaviour', 'Monthly_Balance'],
      dtype='object')
```

In [196]:

```
df.drop('Occupation' , axis =1 , inplace = True)
```

Type *Markdown* and LaTeX: α^2

In [197]:
```
df.describe()
```

Out[197]:

	Annual_Income	Num_Bank_Accounts	Num_Credit_Card	Interest_Rate	Num_of_Loan	Del
count	38912.000000	38912.000000	38912.000000	38912.000000	38912.000000	
mean	7661.399337	16.956389	22.653963	70.375514	97.001619	
std	4398.531779	117.373909	128.218919	457.446740	63.721398	
min	0.000000	-1.000000	0.000000	1.000000	0.000000	
25%	3861.750000	3.000000	4.000000	7.000000	3.000000	
50%	7692.000000	6.000000	5.000000	13.000000	102.000000	
75%	11444.000000	7.000000	7.000000	20.000000	141.000000	
max	15298.000000	1798.000000	1499.000000	5799.000000	219.000000	

In [198]:
```
from sklearn.preprocessing import MaxAbsScaler
```

In [199]:
```
scaler = MaxAbsScaler()
```

In [200]:
```
df['Annual_Income'],df['Changed_Credit_Limit'] , df['Num_Credit_Inquiries'] ,
```

In [201]:
```
df.head()
```

Out[201]:

	Annual_Income	Num_Bank_Accounts	Num_Credit_Card	Interest_Rate	Num_of_Loan	Delay_f
0	0.417949	3	4	3	121	
1	0.417949	3	4	3	121	
2	0.417949	3	4	3	121	
3	0.417949	3	4	3	121	
4	0.802816	2	4	6	3	

Model Selection:

In [202]:
```
from sklearn.ensemble import RandomForestClassifier , ExtraTreesClassifier ,Ad
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
import warnings as w
w.filterwarnings('ignore')
```

In [203]:

```
df.columns
```

Out[203]:

```
Index(['Annual_Income', 'Num_Bank_Accounts', 'Num_Credit_Card',
       'Interest_Rate', 'Num_of_Loan', 'Delay_from_due_date',
       'Changed_Credit_Limit', 'Num_Credit_Inquiries', 'Credit Scores',
       'Outstanding_Debt', 'Credit_Utilization_Ratio', 'Payment_of_Min_Amoun
t',
       'Total_EMI_per_month', 'Payment_Behaviour', 'Monthly_Balance'],
      dtype='object')
```

In [204]:

```
X = df.drop('Credit Scores' , axis =1 )
Y = df[['Credit Scores']]
```

In [205]:

```
xtrain , xtest , ytrain , ytest = train_test_split(X , Y , test_size=.2 , rand
```

In [206]:

```
#AdaBoostClassifier
ada = AdaBoostClassifier()
ada.fit(xtrain , ytrain )
```

Out[206]:

```
AdaBoostClassifier()
```

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On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [207]:

```
ada.score(xtrain , ytrain)
```

Out[207]:

```
0.817790484756979
```

In [208]:

```
ada.score(xtest , ytest)
```

Out[208]:

```
0.8171656173711936
```

In [209]:

```
#RandomForestClassifier
ran = RandomForestClassifier(random_state=100)
```

In [210]:

```
ran.fit(xtrain , ytrain )
```

Out[210]:

```
RandomForestClassifier(random_state=100)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
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In [211]:

```
ran.score(xtest , ytest)
```

Out[211]:

```
0.9509186688937428
```

In [212]:
```
ran.score(xtrain , ytrain)
```

Out[212]:
```
1.0
```

In [213]:
```
#ExtraTreesClassifier
etc = ExtraTreesClassifier(random_state=100)
```

In [214]:
```
etc.fit(xtrain , ytrain)
```

Out[214]:
```
ExtraTreesClassifier(random_state=100)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [215]:
```
etc.score(xtrain , ytrain)
```

Out[215]:
```
1.0
```

In [216]:
```
etc.score(xtest , ytest)
```

Out[216]:
```
0.9225234485416934
```

In [217]:
```
reg = LogisticRegression(random_state=100)
```

In [218]:
```
reg.fit(xtrain , ytrain)
```

Out[218]:
```
LogisticRegression(random_state=100)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [219]:
```
reg.score(xtest , ytest)
```

Out[219]:
```
0.5255043042528588
```

In [220]:
```
reg.score(xtrain , ytrain)
```

Out[220]:
```
0.5186803302386842
```

Model Training

In [221]:
```
from sklearn.metrics import accuracy_score , classification_report ,confusion_
```

In [222]:
```
print(classification_report(ytest , etc.predict(xtest)))
```

```
              precision    recall  f1-score   support

           0       0.91      0.94      0.92      1826
           1       0.91      0.96      0.94      2367
           2       0.94      0.89      0.91      3590

    accuracy                           0.92      7783
   macro avg       0.92      0.93      0.92      7783
weighted avg       0.92      0.92      0.92      7783
```

In [223]:
```
print(classification_report(ytest , ran.predict(xtest)))
```

```
              precision    recall  f1-score   support

           0       0.92      0.98      0.95      1826
           1       0.96      0.97      0.96      2367
           2       0.97      0.93      0.95      3590

    accuracy                           0.95      7783
   macro avg       0.95      0.96      0.95      7783
weighted avg       0.95      0.95      0.95      7783
```

In [224]:
```
confusion_matrix(ytest , ran.predict(xtest))
```

Out[224]:
```
array([[1787,    0,   39],
       [   0, 2289,   78],
       [ 161,  104, 3325]])
```

In [225]:
```
confusion_matrix(ytest , etc.predict(xtest))
```

Out[225]:
```
array([[1717,    0,  109],
       [   0, 2266,  101],
       [ 180,  213, 3197]])
```

Hyperparameter Tuning

In [ ]:
```
#Define hyperparameters for Random Forest
rf_params = {
    'n_estimators': [101, 151, 201, 251, 301], #https://numpy.org/doc/stable/r
    'criterion': ['gini', 'entropy'],
    'max_depth': [None, 2,4,6,8,10,],
    'min_samples_split': [2,3,4,5,6,7,810],
    'min_samples_leaf': [1, 2,3, 4],
    'max_features': ['auto', 'sqrt', 'log2']
}
```

In [ ]:

```
from sklearn.model_selection import  GridSearchCV, RandomizedSearchCV
```

In [ ]:

```
rf_random_search = RandomizedSearchCV(estimator=RandomForestClassifier(random_
                                      param_distributions=rf_params, n_iter=10
rf_random_search.fit(xtrain, ytrain)
```

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In [ ]:

```
rf_random_search.best_params_
```

In [ ]:

```
#laptop problem korsa Hyperparameter Tuning r kora galo na
```