Importing libraries and datasets

In [1]:

```
import numpy as np
import pandas as pd
import datetime as dt

import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split
from imblearn.under_sampling import RandomUnderSampler
from imblearn.over_sampling import RandomOverSampler
from imblearn.over_sampling import SMOTE

from sklearn.linear_model import LogisticRegression
import xgboost as xgb

from sklearn.metrics import precision_score, recall_score, f1_score, auc, roc_auc_score, a
from xgboost import plot_importance
```

In [2]:

```
df_response = pd.read_csv('Retail_Data_Response.csv')
df_transactions = pd.read_csv('Retail_Data_Transactions.csv', parse_dates=['trans_date'])
```

In [3]:

```
df_response.head()
```

Out[3]:

	customer_id	response
0	CS1112	0
1	CS1113	0
2	CS1114	1
3	CS1115	1
4	CS1116	1

In [4]:

```
df_transactions.head()
```

Out[4]:

	customer_id	trans_date	tran_amount
0	CS5295	2013-02-11	35
1	CS4768	2015-03-15	39
2	CS2122	2013-02-26	52
3	CS1217	2011-11-16	99
4	CS1850	2013-11-20	78

In [5]:

```
print(df_transactions['trans_date'].min())
print(df_transactions['trans_date'].max())
```

```
2011-05-16 00:00:00
2015-03-16 00:00:00
```

Data Preparation

In [6]:

```
## since the last date of the data is 16 March 2015, the campaign date is assumed to be 1

campaign_date = dt.datetime(2015,3,17)
df_transactions['recent']= campaign_date - df_transactions['trans_date']
df_transactions['recent'].astype('timedelta64[D]')
df_transactions['recent']= df_transactions['recent'] / np.timedelta64(1, 'D')
df_transactions.head()
```

Out[6]:

	customer_id	trans_date	tran_amount	recent
0	CS5295	2013-02-11	35	764.0
1	CS4768	2015-03-15	39	2.0
2	CS2122	2013-02-26	52	749.0
3	CS1217	2011-11-16	99	1217.0
4	CS1850	2013-11-20	78	482.0

In [7]:

```
## create data set with CLV variables

df_clv = df_transactions.groupby('customer_id').agg({'recent': lambda x:x.min(),
                                                      'customer_id': lambda x: len(x),
                                                      'tran_amount': lambda x: x.sum(),
                                                      'trans_date': lambda x: (x.max() - x.

df_clv.rename(columns={'recent': 'recency',
                       'customer_id': 'frequency',
                       'tran_amount': 'monetary_value',
                       'trans_date' : 'AOU'}, inplace=True)

df_clv['avg_size'] = df_clv['monetary_value'] / df_clv['frequency']
```

In [8]:

```
df_clv = df_clv.reset_index()
df_clv.head()
```

Out[8]:

	customer_id	recency	frequency	monetary_value	AOU	avg_size
0	CS1112	62.0	15	1012	1309	67.466667
1	CS1113	36.0	20	1490	1354	74.500000
2	CS1114	33.0	19	1432	1309	75.368421
3	CS1115	12.0	22	1659	1303	75.409091
4	CS1116	204.0	13	857	1155	65.923077

Calculating response rate

In [9]:

```
response_rate = df_response.groupby('response').agg({'customer_id': lambda x: len(x)}).res
response_rate.head()
```

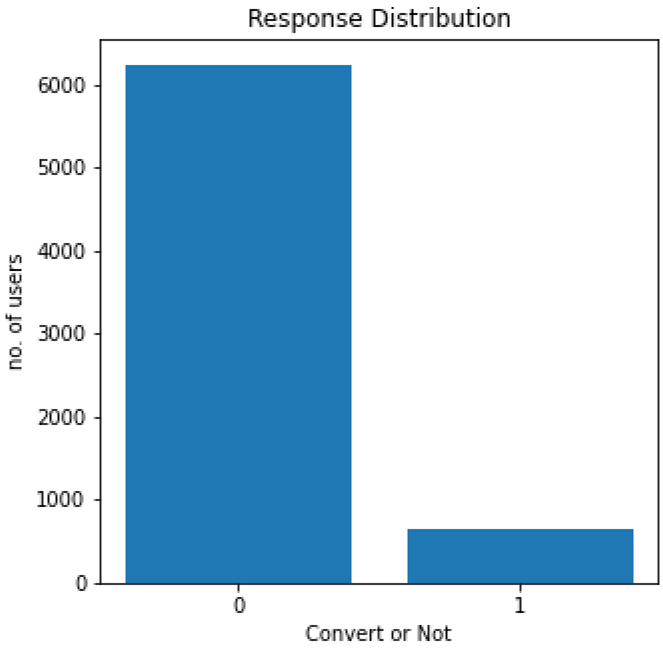
Out[9]:

	response	customer_id
0	0	6237

	response	customer_id
1	1	647

In [10]:

```
plt.figure(figsize=(5,5))
x=range(2)
plt.bar(x,response_rate['customer_id'])
plt.xticks(response_rate.index)
plt.title('Response Distribution')
plt.xlabel('Convert or Not')
plt.ylabel('no. of users')
plt.show()

## data is imbalanced
```



In [11]:

```
## merging two data sets - CLV

df_modeling_clv = pd.merge(df_response,df_clv)
df_modeling_clv.head()
```

Out[11]:

	customer_id	response	recency	frequency	monetary_value	AOU	avg_size
0	CS1112	0	62.0	15	1012	1309	67.466667
1	CS1113	0	36.0	20	1490	1354	74.500000
2	CS1114	1	33.0	19	1432	1309	75.368421
3	CS1115	1	12.0	22	1659	1303	75.409091
4	CS1116	1	204.0	13	857	1155	65.923077

Creating train and test dataset

In [12]:

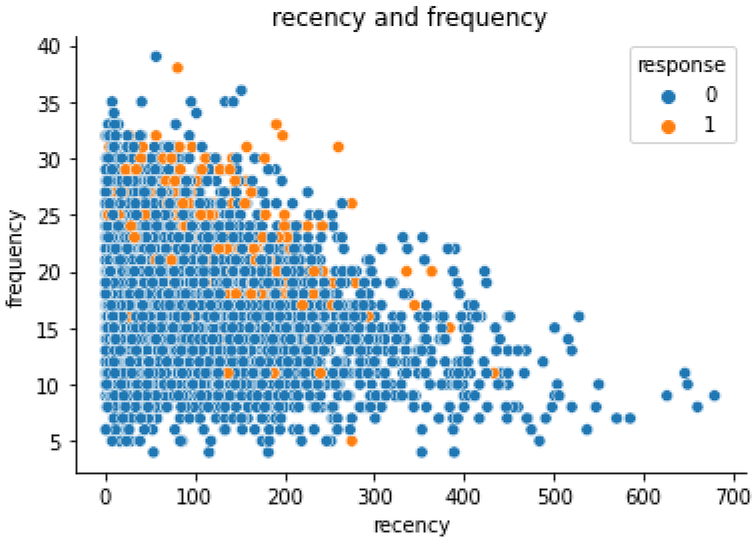
```
## spliting dataframe into X and y

X_clv = df_modeling_clv.drop(columns=['response','customer_id'])
y_clv = df_modeling_clv['response']
```

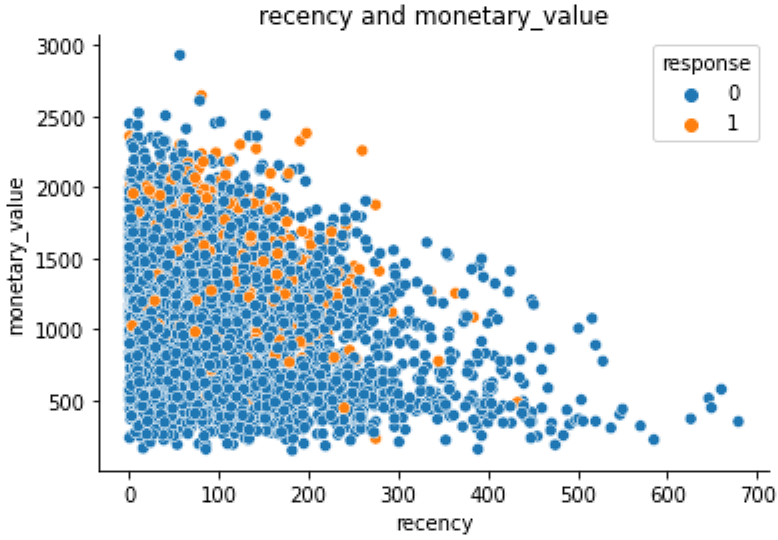
In [13]:

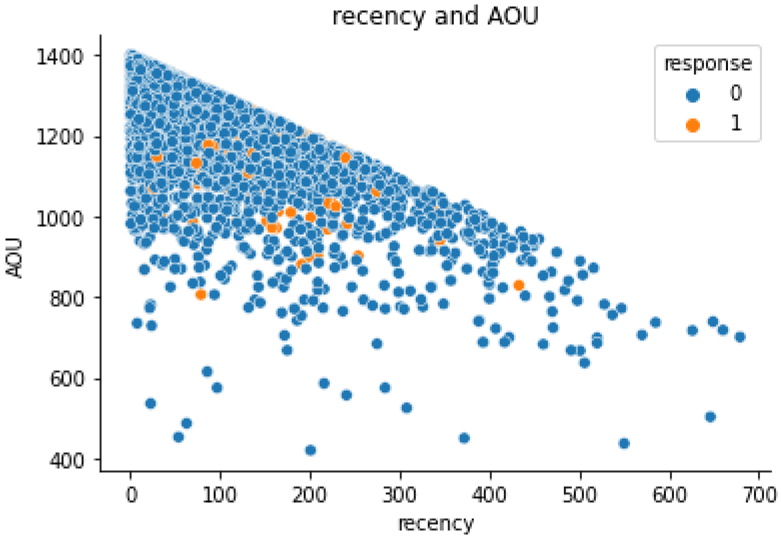
```
## creating train and test dataset
X_train_clv, X_test_clv, y_train_clv, y_test_clv = train_test_split(X_clv, y_clv, test_siz
```

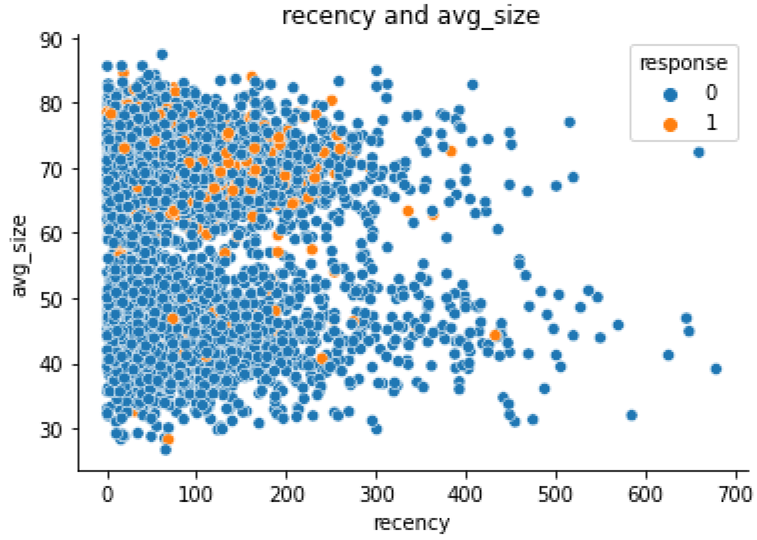
In [14]:

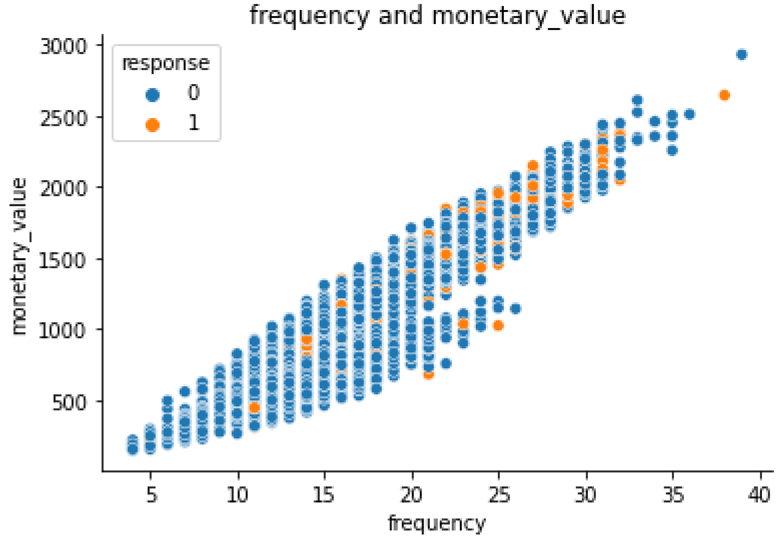
```
for i, col_i in enumerate(df_modeling_clv[['recency', 'frequency', 'monetary_value', 'AOU'
  for j, col_j in enumerate(df_modeling_clv[['recency', 'frequency', 'monetary_value', 'AO
    if i < j :
      plt.title(col_i + ' and ' + col_j)
      sns.scatterplot(data=df_modeling_clv, x=col_i, y=col_j, hue='response')
      sns.despine()
      plt.show()
```

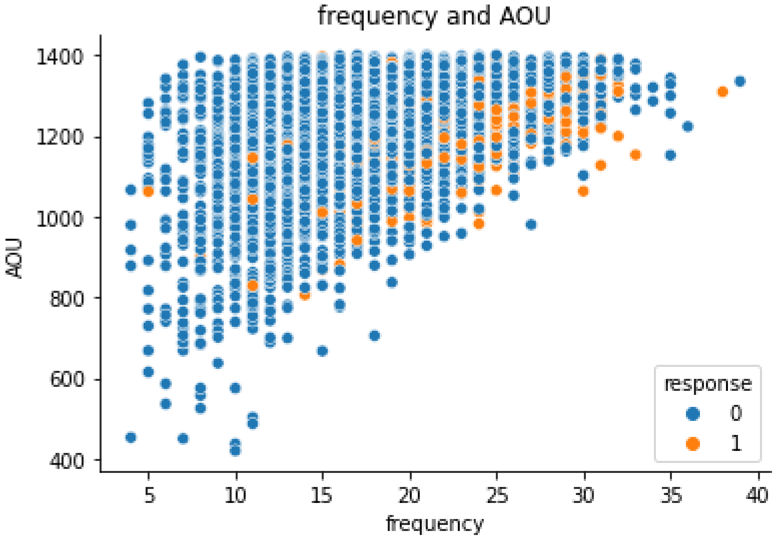




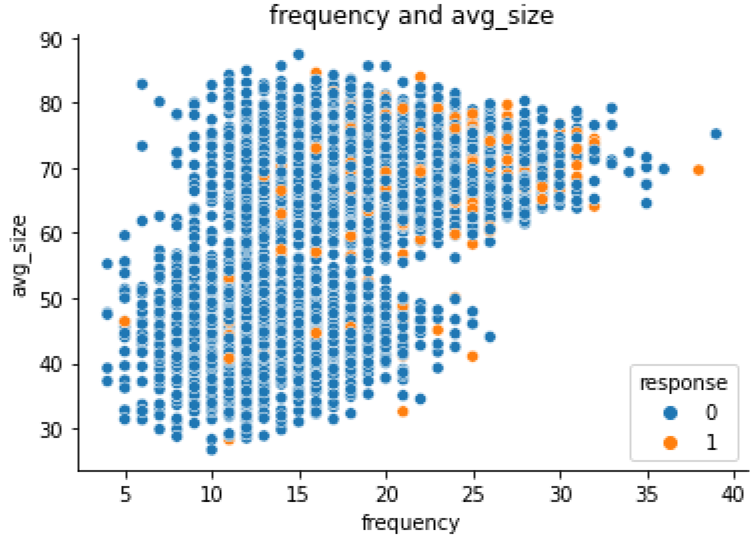

recency and AOU


recency and avg_size

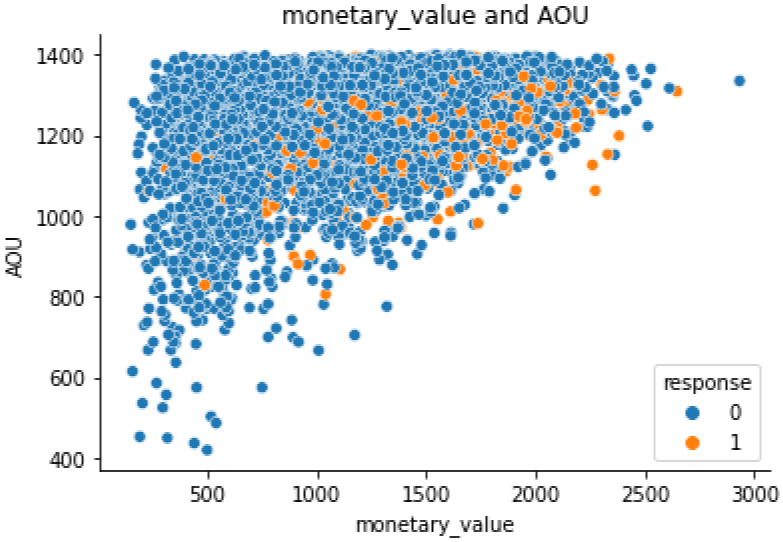

frequency and monetary_value



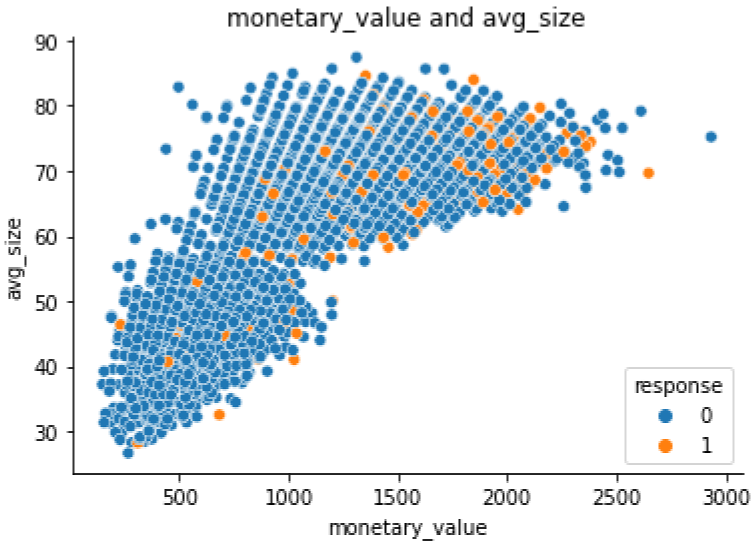
frequency and AOU

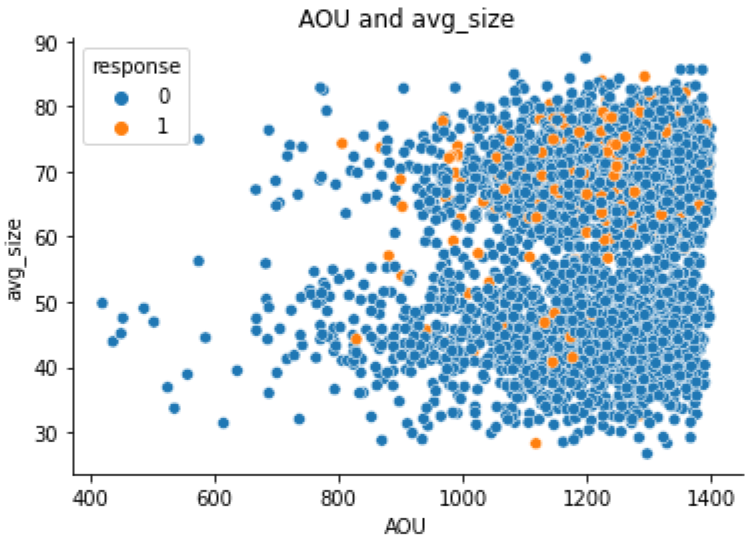


frequency and avg_size



monetary_value and AOU





In [15]:

```
corrM = df_modeling_clv.corr()
corrM
```

Out[15]:

	response	recency	frequency	monetary_value	AOU	avg_size
response	1.000000	0.023405	0.201333	0.205543	0.002463	0.142133
recency	0.023405	1.000000	-0.286019	-0.270120	-0.715406	-0.176771
frequency	0.201333	-0.286019	1.000000	0.934468	0.401191	0.535893
monetary_value	0.205543	-0.270120	0.934468	1.000000	0.376935	0.786731
AOU	0.002463	-0.715406	0.401191	0.376935	1.000000	0.245546
avg_size	0.142133	-0.176771	0.535893	0.786731	0.245546	1.000000

Fixing imbalanced with SMOTE

In [16]:

```
sm = SMOTE(random_state=0)

sm.fit(X_train_clv, y_train_clv)
X_SMOTE_clv, y_SMOTE_clv = sm.fit_resample(X_train_clv, y_train_clv)
```

Modeling

In [18]:

```
from sklearn.model_selection import train_test_split, GridSearchCV, StratifiedKFold
from sklearn.ensemble import RandomForestClassifier, BaggingClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_curve, roc_auc_score
from sklearn.neighbors import KNeighborsClassifier
from sklearn.pipeline import Pipeline
from sklearn.linear_model import SGDClassifier

'''Build pipline of classifiers'''
random_state = 11
# set all CPU
n_jobs = -1
# LogisticRegression
pipe_lr = Pipeline([('lr', LogisticRegression(random_state=random_state, n_jobs=n_jobs, ma
# RandomForestClassifier
pipe_rf = Pipeline([('rf', RandomForestClassifier(random_state=random_state, oob_score=Tru
# KNeighborsClassifier
pipe_knn = Pipeline([('knn', KNeighborsClassifier(n_jobs=n_jobs))])
# DecisionTreeClassifier
pipe_dt = Pipeline([('dt', DecisionTreeClassifier(random_state=random_state, max_features=
# BaggingClassifier
# note we use SGDClassifier as classier inside BaggingClassifier
pipe_bag = Pipeline([('bag',BaggingClassifier(base_estimator=SGDClassifier(random_state=ra
                                              random_state=random_state,oob_score=True,n_j
```

In [19]:

```
'''Set parameters for Grid Search '''
# set number
cv = StratifiedKFold(shuffle=True, n_splits=5, random_state=random_state)
# set for LogisticRegression
grid_params_lr = [{
                'lr__penalty': ['l2'],
                'lr__C': [0.3, 0.6, 0.7],
                'lr__solver': ['sag']
                }]
# set for RandomForestClassifier
grid_params_rf = [{
                'rf__criterion': ['entropy'],
                'rf__min_samples_leaf': [80, 100],
                'rf__max_depth': [25, 27],
                'rf__min_samples_split': [3, 5],
                'rf__n_estimators' : [60, 70]
                }]
# set for KNeighborsClassifier
grid_params_knn = [{'knn__n_neighbors': [16,17,18]}]

# set for DecisionTreeClassifier
grid_params_dt = [{
                'dt__max_depth': [8, 10],
                'dt__min_samples_leaf': [1, 3, 5, 7]
                  }]
# set for BaggingClassifier
grid_params_bag = [{'bag__n_estimators': [20, 25, 30]}]
```

In [20]:

```
'''Grid search objects'''
# for LogisticRegression
gs_lr = GridSearchCV(pipe_lr, param_grid=grid_params_lr,
                     scoring='accuracy', cv=cv)
# for RandomForestClassifier
gs_rf = GridSearchCV(pipe_rf, param_grid=grid_params_rf,
                     scoring='accuracy', cv=cv)
# for KNeighborsClassifier
```

```
gs_knn = GridSearchCV(pipe_knn, param_grid=grid_params_knn,
                     scoring='accuracy', cv=cv)
# for DecisionTreeClassifier
gs_dt = GridSearchCV(pipe_dt, param_grid=grid_params_dt,
                     scoring='accuracy', cv=cv)
# for BaggingClassifier
gs_bag = GridSearchCV(pipe_bag, param_grid=grid_params_bag,
                     scoring='accuracy', cv=cv)
```

In [21]:

```
# models that we iterate over
look_for = [gs_lr, gs_rf, gs_knn, gs_dt, gs_bag]
# dict for later use
model_dict = {0:'Logistic_reg', 1:'RandomForest', 2:'Knn', 3:'DesionTree', 4:'Bagging witl
```

In [22]:

```
''' Function to iterate over models and obtain results'''
# set empty dicts and list
result_acc = {}
result_auc = {}
models = []

for index, model in enumerate(look_for):
        print('+++++++ Start New Model ++++++++++++++++++++++')
        print('Estimator is {}'.format(model_dict[index]))
        model.fit(X_SMOTE_clv, y_SMOTE_clv)
        print('---------------------------------------------')
        print('best params {}'.format(model.best_params_))
        print('best score is {}'.format(model.best_score_))
        auc = roc_auc_score(y_test_clv, model.predict_proba(X_test_clv)[:,1])
        print('---------------------------------------------')
        print('Test Set')
        print('---------------------------------------------')
        print('ROC_AUC is {} and accuracy rate is {}'.format(auc, model.score(X_test_clv,
        print('---------------------------------------------')
        print('Train Set')
        auc_train = roc_auc_score(y_SMOTE_clv, model.predict_proba(X_SMOTE_clv)[:,1])
        print('ROC_AUC_train is {} and accuracy rate is {}'.format(auc_train, model.score
        print('---------------------------------------------')


        print('++++++++ End Model +++++++++++++++++++++++++++')
        models.append(model.best_estimator_)
        result_acc[index] = model.best_score_
        result_auc[index] = auc
```

```
+++++++ Start New Model ++++++++++++++++++++++
Estimator is Logistic_reg
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\linear_mode
l\_sag.py:352: ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
---------------------------------------------
best params {'lr__C': 0.3, 'lr__penalty': 'l2', 'lr__solver': 'sag'}
best score is 0.6708014667994657
---------------------------------------------
Test Set
---------------------------------------------
ROC_AUC is 0.7180303743819166 and accuracy rate is 0.6514161220043573
---------------------------------------------
Train Set
ROC_AUC_train is 0.7326940891370924 and accuracy rate is 0.6723033820292176
---------------------------------------------
++++++++ End Model +++++++++++++++++++++++++++
+++++++ Start New Model ++++++++++++++++++++++
Estimator is RandomForest
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\base.py:44
1: UserWarning: X does not have valid feature names, but RandomForestClassifier was fitted
with feature names
  warnings.warn(
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\base.py:44
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```

```
ith feature names
  warnings.warn(
---------------------------------------------
best params {'rf__criterion': 'entropy', 'rf__max_depth': 25, 'rf__min_samples_leaf': 80,
'rf__min_samples_split': 3, 'rf__n_estimators': 60}
best score is 0.720532788916981
---------------------------------------------
Test Set
---------------------------------------------
ROC_AUC is 0.706516364492583 and accuracy rate is 0.6514161220043573
---------------------------------------------
Train Set
ROC_AUC_train is 0.8332747096727118 and accuracy rate is 0.7470482289373624
---------------------------------------------
++++++++ End Model ++++++++++++++++++++++++++
+++++++ Start New Model +++++++++++++++++++++
Estimator is Knn
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\base.py:44
1: UserWarning: X does not have valid feature names, but KNeighborsClassifier was fitted w
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1: UserWarning: X does not have valid feature names, but KNeighborsClassifier was fitted w
ith feature names
  warnings.warn(
---------------------------------------------
best params {'knn__n_neighbors': 16}
best score is 0.792475416887623
---------------------------------------------
Test Set
---------------------------------------------
ROC_AUC is 0.6550829997645397 and accuracy rate is 0.6833696441539578
---------------------------------------------
Train Set
ROC_AUC_train is 0.924487752487394 and accuracy rate is 0.8265959575745447
---------------------------------------------
++++++++ End Model +++++++++++++++++++++++++++
+++++++ Start New Model ++++++++++++++++++++++
Estimator is DesionTree
---------------------------------------------
best params {'dt__max_depth': 10, 'dt__min_samples_leaf': 3}
best score is 0.7474487994748126
---------------------------------------------
Test Set
---------------------------------------------
ROC_AUC is 0.6029932893807393 and accuracy rate is 0.654320987654321
---------------------------------------------
Train Set
ROC_AUC_train is 0.8741798010565395 and accuracy rate is 0.7889733840304183
---------------------------------------------
++++++++ End Model +++++++++++++++++++++++++++
+++++++ Start New Model ++++++++++++++++++++++
Estimator is Bagging with SGDClassifier
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\ensemble\_b
agging.py:706: UserWarning: Some inputs do not have OOB scores. This probably means too fe
w estimators were used to compute any reliable oob estimates.
  warn(
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\ensemble\_b
agging.py:712: RuntimeWarning: invalid value encountered in true_divide
  oob_decision_function = predictions / predictions.sum(axis=1)[:, np.newaxis]
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\ensemble\_b
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```

```
  oob_decision_function = predictions / predictions.sum(axis=1)[:, np.newaxis]
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agging.py:712: RuntimeWarning: invalid value encountered in true_divide
  oob_decision_function = predictions / predictions.sum(axis=1)[:, np.newaxis]
---------------------------------------------
best params {'bag__n_estimators': 25}
best score is 0.6481902612968147
---------------------------------------------
Test Set
---------------------------------------------
ROC_AUC is 0.7312308688485989 and accuracy rate is 0.6855482933914306
---------------------------------------------
Train Set
ROC_AUC_train is 0.7215105929677479 and accuracy rate is 0.6534920952571542
---------------------------------------------
++++++++ End Model ++++++++++++++++++++++++++
```

In [23]:

```python
predicted_y = []
expected_y = []
predictions = gs_bag.predict(X_test_clv.to_numpy())
predicted_y.extend(predictions)
expected_y.extend(y_test_clv)
report_test = classification_report(expected_y, predicted_y)
print('test set')
print(report_test)
```

```
C:\Users\S540\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\base.py:44
1: UserWarning: X does not have valid feature names, but BaggingClassifier was fitted with
feature names
  warnings.warn(
test set
              precision    recall  f1-score   support

           0       0.94      0.69      0.80      1240
           1       0.19      0.64      0.29       137

    accuracy                           0.69      1377
   macro avg       0.56      0.66      0.54      1377
weighted avg       0.87      0.69      0.75      1377
```

The best model is SGDClassifier The AUC train = 0.721 The AUC test = 0.731