Sentimental Analysis for E-Commerce Websites

Team 16

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Importing Libraries

```
# !pip install pyforest
# 1-Import Libraies
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import scipy.stats as stats
%matplotlib inline
import statsmodels.api as sm
import statsmodels.formula.api as smf
import missingno as msno

from sklearn.compose import make_column_transformer

# Scaling
from sklearn.preprocessing import scale
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import PolynomialFeatures
from sklearn.preprocessing import OneHotEncoder
from sklearn.preprocessing import PowerTransformer
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import RobustScaler


# Importing plotly and cufflinks in offline mode
import plotly.express as px
import cufflinks as cf
import plotly.offline
cf.go_offline()
cf.set_config_file(offline=False, world_readable=True)

# Ignore Warnings
import warnings
```

```
warnings.filterwarnings("ignore")
warnings.warn("this will not show")

# Figure&Display options
plt.rcParams["figure.figsize"] = (10,6)
pd.set_option('max_colwidth',200)
pd.set_option('display.max_rows', 1000)
pd.set_option('display.max_columns', 200)
pd.set_option('display.float_format', lambda x: '%.3f' % x)

# !pip install termcolor
import colorama
from colorama import Fore, Style  # maakes strings colored
from termcolor import colored

import ipywidgets
from ipywidgets import interact

import nltk
from nltk.tokenize import sent_tokenize, word_tokenize
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
from nltk.stem import PorterStemmer
from collections import Counter
from wordcloud import WordCloud
```

Exploratory Data Analysis

```
## Some Useful Functions

##############################################################################

def missing_values(df):
    missing_number = df.isnull().sum().sort_values(ascending=False)
    missing_percent = (df.isnull().sum()/df.isnull().count()).sort_values(ascending=Fa
    missing_values = pd.concat([missing_number, missing_percent], axis=1, keys=['Missi
    return missing_values[missing_values['Missing_Number']>0]

##############################################################################

def first_looking(df):
    print(colored("Shape:", attrs=['bold']), df.shape,'\n',
          colored('-'*79, 'red', attrs=['bold']),
          colored("\nInfo:\n", attrs=['bold']), sep='')
    print(df.info(), '\n',
          colored('-'*79, 'red', attrs=['bold']), sep='')
    print(colored("Number of Uniques:\n", attrs=['bold']), df.nunique(),'\n',
          colored('-'*79, 'red', attrs=['bold']), sep='')
```

```
    print(colored("Missing Values:\n", attrs=['bold']), missing_values(df),'\n',
          colored('-'*79, 'red', attrs=['bold']), sep='')
    print(colored("All Columns:", attrs=['bold']), list(df.columns),'\n',
          colored('-'*79, 'red', attrs=['bold']), sep='')

    df.columns= df.columns.str.lower().str.replace('&', '_').str.replace(' ', '_')

    print(colored("Columns after rename:", attrs=['bold']), list(df.columns),'\n',
              colored('-'*79, 'red', attrs=['bold']), sep='')


def multicolinearity_control(df):
    feature =[]
    collinear=[]
    for col in df.corr().columns:
        for i in df.corr().index:
            if (abs(df.corr()[col][i])> .9 and abs(df.corr()[col][i]) < 1):
                    feature.append(col)
                    collinear.append(i)
                    print(colored(f"Multicolinearity alert in between:{col} - {i}",
                                  "red", attrs=['bold']), df.shape,'\n',
                                  colored('-'*79, 'red', attrs=['bold']), sep='')

def duplicate_values(df):
    print(colored("Duplicate check...", attrs=['bold']), sep='')
    duplicate_values = df.duplicated(subset=None, keep='first').sum()
    if duplicate_values > 0:
        df.drop_duplicates(keep='first', inplace=True)
        print(duplicate_values, colored("Duplicates were dropped!"),'\n',
              colored('-'*79, 'red', attrs=['bold']), sep='')
    else:
        print(colored("There are no duplicates"),'\n',
              colored('-'*79, 'red', attrs=['bold']), sep='')

def drop_columns(df, drop_columns):
    if drop_columns !=[]:
        df.drop(drop_columns, axis=1, inplace=True)
        print(drop_columns, 'were dropped')
    else:
        print(colored('We will now check the missing values and if necessary will drop
              colored('-'*79, 'red', attrs=['bold']), sep='')

def drop_null(df, limit):
    print('Shape:', df.shape)
    for i in df.isnull().sum().index:
        if (df.isnull().sum()[i]/df.shape[0]*100)>limit:
            print(df.isnull().sum()[i], 'percent of', i ,'null and were dropped')
            df.drop(i, axis=1, inplace=True)
            print('new shape:', df.shape)
    print('New shape after missing value control:', df.shape)
```

```
##############################################################################

# To view summary information about the column

def first_look(col):
    print("column name    : ", col)
    print("--------------------------------")
    print("per_of_nulls   : ", "%", round(df[col].isnull().sum()/df.shape[0]*100, 2))
    print("num_of_nulls   : ", df[col].isnull().sum())
    print("num_of_uniques : ", df[col].nunique())
    print(df[col].value_counts(dropna = False))


df = pd.read_csv("Womens Clothing E-Commerce Reviews.csv")
df.head()
```

	Unnamed: 0	Clothing ID	Age	Title	Review Text	Rating	Recommended IND	Positive Feedback Count	Di
0	0	767	33	NaN	Absolutely wonderful - silky and sexy and comfortable	4	1	0	I
1	1	1080	34	NaN	Love this dress! it's sooo pretty. i happened to find it in a store, and i'm glad i did bc i never would have ordered it online bc it's petite. i bought a petite and	5	1	4	

```
first_looking(df)
duplicate_values(df)
drop_columns(df,[])
drop_null(df, 90)
```

```
    Shape:(23486, 11)
    ------------------------------------------------------------------------------
    Info:

    <class 'pandas.core.frame.DataFrame'>
    RangeIndex: 23486 entries, 0 to 23485
    Data columns (total 11 columns):
     #   Column                   Non-Null Count  Dtype
```

```
---  ------                   --------------  -----
 0   Unnamed: 0               23486 non-null  int64
 1   Clothing ID              23486 non-null  int64
 2   Age                      23486 non-null  int64
 3   Title                    19676 non-null  object
 4   Review Text              22641 non-null  object
 5   Rating                   23486 non-null  int64
 6   Recommended IND          23486 non-null  int64
 7   Positive Feedback Count  23486 non-null  int64
 8   Division Name            23472 non-null  object
 9   Department Name          23472 non-null  object
 10  Class Name               23472 non-null  object
dtypes: int64(6), object(5)
memory usage: 2.0+ MB
None
--------------------------------------------------------------------------------
Number of Uniques:
Unnamed: 0                 23486
Clothing ID                 1206
Age                           77
Title                      13993
Review Text                22634
Rating                         5
Recommended IND                2
Positive Feedback Count       82
Division Name                  3
Department Name                6
Class Name                    20
dtype: int64
--------------------------------------------------------------------------------
Missing Values:
                 Missing_Number  Missing_Percent
Title                      3810            0.162
Review Text                 845            0.036
Division Name                14            0.001
Department Name              14            0.001
Class Name                   14            0.001
--------------------------------------------------------------------------------
All Columns:['Unnamed: 0', 'Clothing ID', 'Age', 'Title', 'Review Text', 'Rating
--------------------------------------------------------------------------------
Columns after rename:['unnamed:_0', 'clothing_id', 'age', 'title', 'review_text'
--------------------------------------------------------------------------------
Duplicate check...
There are no duplicates
--------------------------------------------------------------------------------
We will now check the missing values and if necessary will drop related columns!
--------------------------------------------------------------------------------
Shape: (23486, 11)
New shape after missing value control: (23486, 11)
```

```
df.drop(['unnamed:_0', 'clothing_id'], axis = 1, inplace=True)
```

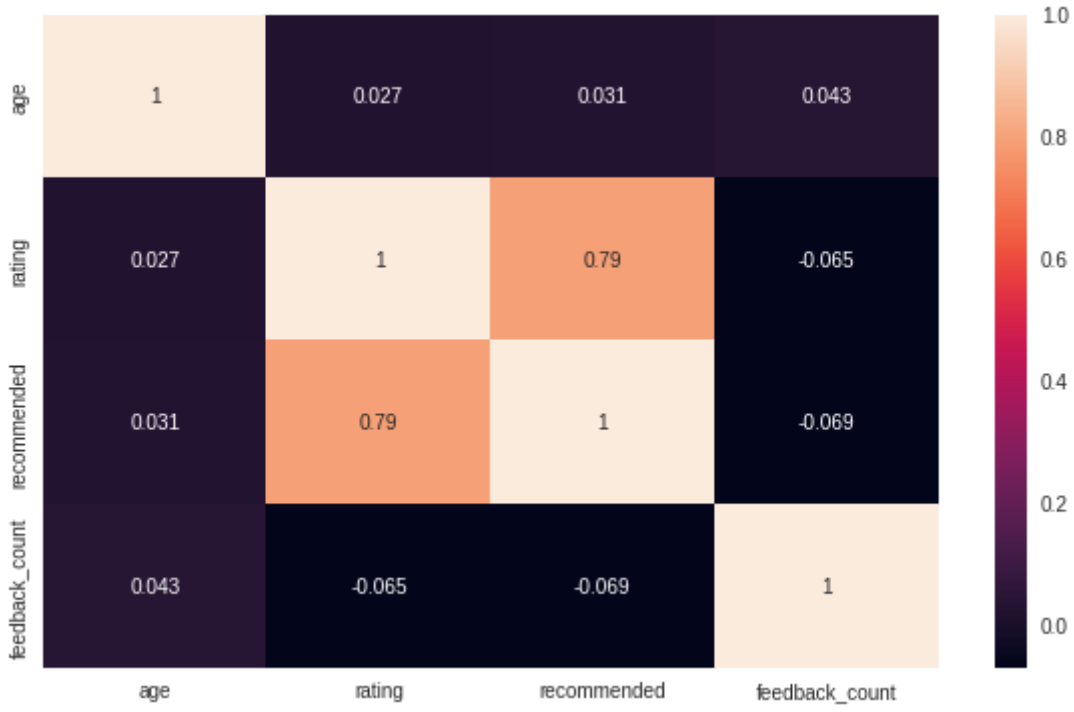
```
df = df.rename(columns = {'Review Text' : 'text', 'recommended_ind' : 'recommended',
                          'positive_feedback_count' : 'feedback_count', 'division_name
```

```
                                'department_name' : 'department', 'class_name' :'class'})
```

```
df.describe(include=object).T
```

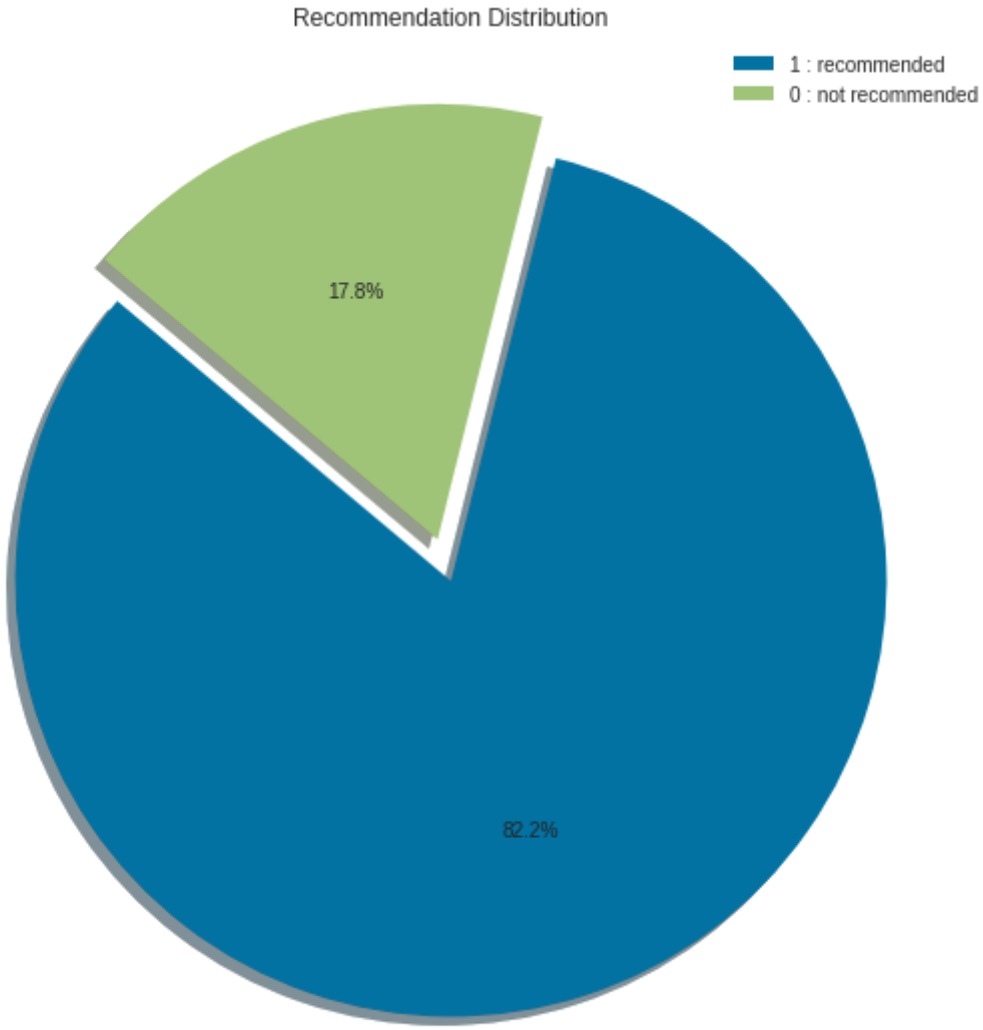
	count	unique	
title	19676	13993	
review_text	22641	22634	Perfect fit and i've gotten so many compliments. i buy all my suits from he
division	23472	3	(
department	23472	6	
class	23472	20	[

```
sns.heatmap(df.corr(), annot=True);
```




```
# recommended :
# Binary variable stating where the customer recommends the product where 1 is recomme

print(df.recommended.value_counts())

plt.figure(figsize=(10,10))

explode = [0,0.1]
plt.pie(df.recommended.value_counts(), explode=explode,autopct='%1.1f%%', shadow=True,
plt.legend(labels=['1 : recommended','0 : not recommended'])
plt.title('Recommendation Distribution')
plt.axis('off');
```

```
1    19314
0     4172
Name: recommended, dtype: int64
```



Feature Selection and Data Cleaning

```
df_ml = df.copy()

# df_ml = df[['review_text', 'recommended']].copy()


drop_columns = ['age',
                'title',
                'rating',
                'feedback_count',
                'division',
                'department',
                'class']
```

```
df_ml.drop(drop_columns, axis = 1, inplace = True)
```

```
df_ml.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 23486 entries, 0 to 23485
Data columns (total 2 columns):
 #   Column       Non-Null Count  Dtype 
---  ------       --------------  ----- 
 0   review_text  22641 non-null  object
 1   recommended  23486 non-null  int64 
dtypes: int64(1), object(1)
memory usage: 367.1+ KB
```

```
df_ml.rename(columns = {'review_text':'text', 'recommended':'recommend'}, inplace = Tı
```

```
df_ml.columns
```

```
Index(['text', 'recommend'], dtype='object')
```

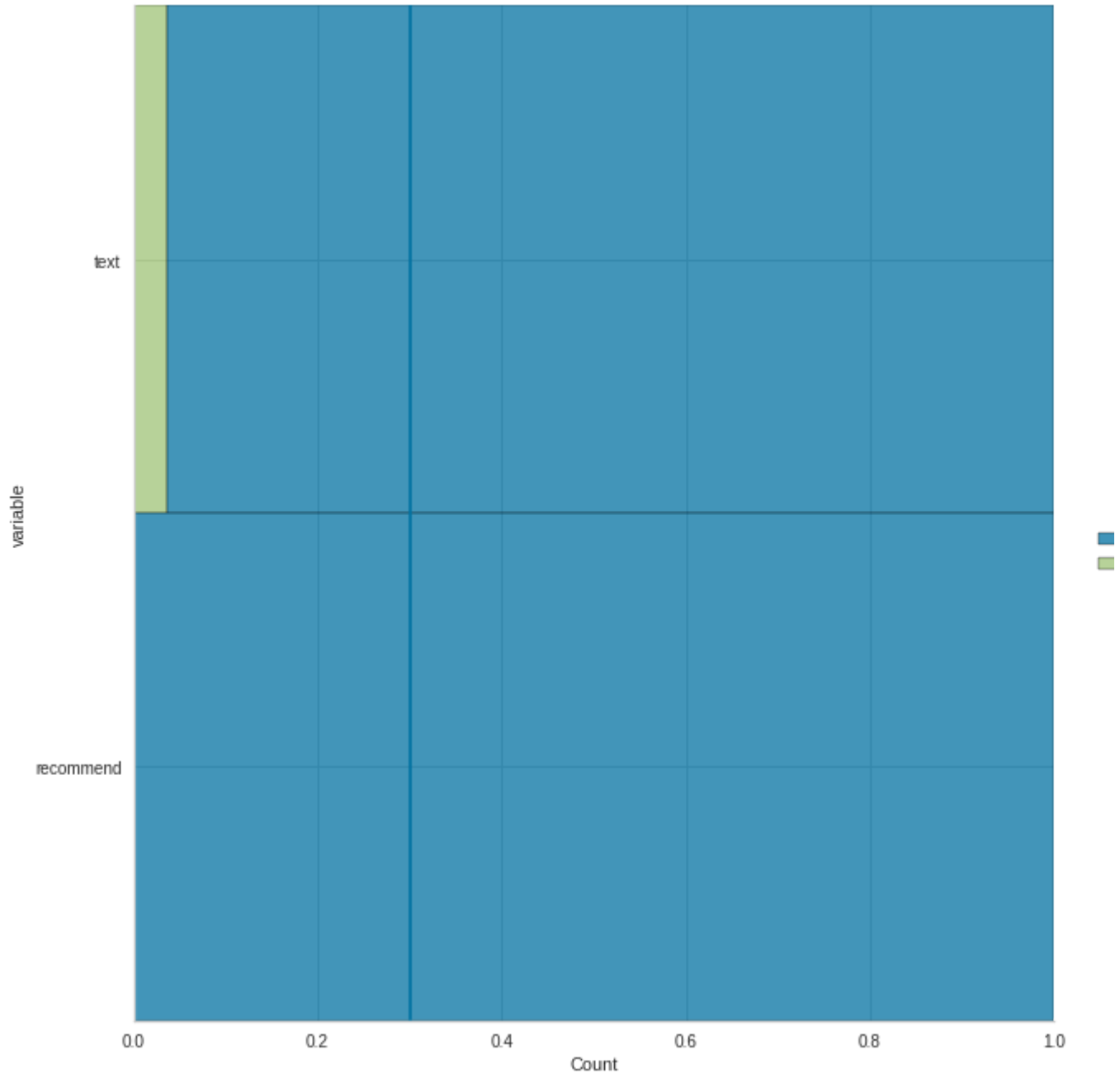
```
missing_values(df_ml)
```

	Missing_Number	Missing_Percent
text	845	0.036

```
df_ml.isnull().melt(value_name="missing")
```

```
plt.figure(figsize = (10, 5))
sns.displot(data = df_ml.isnull().melt(value_name = "missing"),y = "variable",hue = "m
plt.axvline(0.3, color = "b");
```

```
<Figure size 720x360 with 0 Axes>
```




```
df_ml = df_ml.dropna()

# df_ml = df_ml.dropna(subset=['text'], axis=0)
# df_ml = df_ml.reset_index(drop=True)


missing_values(df_ml)
```

```
        Missing Number  Missing Percent
```

```
df_ml.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 22641 entries, 0 to 23485
Data columns (total 2 columns):
 #   Column     Non-Null Count  Dtype 
---  ------     --------------  ----- 
 0   text       22641 non-null  object
 1   recommend  22641 non-null  int64 
dtypes: int64(1), object(1)
memory usage: 530.6+ KB
```

```
df_ml["text"].str.isspace().sum()
df_ml[df_ml["text"].str.isspace() == True].index
```

```
Int64Index([], dtype='int64')
```

Text Mining

Tokenization, Noise Removal and Lexicon Normalization

```
df_ml.head()
```

0	
1	Love this dress! it's sooo pretty. i happened to find it in a store, and i'm glad i did bc i never would hav
2	I had such high hopes for this dress and really wanted it to work for me. i initially ordered the petite sma
3	I love, love, love this jumpsuit. it's f
4	This shirt is very flattering to all due to the adjustable front tie. it is the perfect length to wear wit

```
import nltk
nltk.download('stopwords')
nltk.download('punkt')
nltk.download('omw-1.4')
stop_words = stopwords.words('english')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package omw-1.4 to /root/nltk_data...
[nltk_data]   Package omw-1.4 is already up-to-date!
```

```
def cleaning(data):

    text_tokens = word_tokenize(data.replace("'", "").lower()) #1. Tokenize
    tokens_without_punc = [w for w in text_tokens if w.isalpha()]  #2. Remove Puncs
    tokens_without_sw = [t for t in tokens_without_punc if t not in stop_words] #3. Re
    text_cleaned = [WordNetLemmatizer().lemmatize(t) for t in tokens_without_sw]  #4.
    return " ".join(text_cleaned) #joining


nltk.download('wordnet')
df_ml["text"] = df_ml["text"].apply(cleaning)
df_ml["text"].head()
```

```
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
0
absolutely wonderful silky sexy comfortable
1                        love dress sooo pretty happened find store im glad bc
never would ordered online bc petite bought petite love length hit little knee
would definitely true midi someone truly petite
2    high hope dress really wanted work initially ordered petite small usual
size found outrageously small small fact could zip reordered petite medium
overall top half comfortable fit nicely bottom ha...
3
love love love jumpsuit fun flirty fabulous every time wear get nothing great
compliment
4
shirt flattering due adjustable front tie perfect length wear legging sleeveless
pair well cardigan love shirt
Name: text, dtype: object
```

WordCloud - Repetition of Words

```
df_ml[df_ml["recommend"] == 0].head(3)
```

2	high hope dress really wanted work initially ordered petite small usual size found outrageously small sı
5	love tracy reese dress one petite foot tall usually wear brand dress pretty package lot dress skirt
10	dress run small esp zipper area run ordered sp typically fit tight material top look feel cheap even pu

```
df_ml[df_ml["recommend"] == 1].head(3)
```

0

1 love dress sooo pretty happened find store im glad bc never would ordered online bc petite bought petite

3 love love love ju

```
" ".join(df_ml["text"]).split()
```

```
 'look',
 'online',
 'person',
 'much',
 'cuter',
 'stripe',
 'brighter',
 'fit',
 'flattering',
 'crop',
 'cute',
 'flare',
 'right',
 'trend',
 'brand',
 'always',
 'run',
 'small',
 'carry',
 'chubbiness',
 'belly',
 'paired',
 'collarless',
 'loose',
 'navy',
 'blazer',
 'pant',
 'even',
 'better',
 'person',
 'downside',
 'need',
 'dry',
 'cleaned',
 'ordered',
 'month',
 'ago',
 'finally',
 'came',
 'back',
 'order',
 'huge',
 'disappointment',
 'fit',
 'much',
 'issue',
 'quality',
```

```
        'wool',
        'subpar',
        'someone',
        'else',
        'mentioned',
        'quot',
        'felted',
        'wool',
        'quot',
        'guess',
        ...]
```

```
positive_words =" ".join(df_ml[df_ml["recommend"] == 1].text).split()
positive_words
```

```
        'fabric',
        'easily',
        'stretched',
        'dont',
        'mind',
        'case',
        'finally',
        'color',
        'look',
        'white',
        'monitor',
        'show',
        'colorful',
        'blue',
        'dot',
        'tried',
        'today',
        'local',
        'retailer',
        'comfortable',
        'flattering',
        'bad',
        'picture',
        'online',
        'model',
        'tucking',
        'skirt',
        'cant',
        'see',
        'ruching',
        'across',
        'front',
        'little',
        'dressier',
        'alternative',
        'plain',
        'tee',
        'reasonably',
        'priced',
        'retailer',
        'generally',
```

```
        'wear',
        'small',
        'fit',
        'well',
        'probably',
        'back',
        'black',
        'bought',
        'item',
        'online',
        'fit',
        'model',
        'looked',
        'little',
        'loose',
        'got',
        ...]
```

```
negative_words =" ".join(df_ml[df_ml["recommend"] == 0].text).split()
negative_words
```

```
       'appear',
       'slimmer',
       'unfortunately',
       'sweater',
       'work',
       'hourglass',
       'shape',
       'shirt',
       'make',
       'look',
       'pound',
       'heavier',
       'worried',
       'item',
       'ordered',
       'look',
       'picture',
       'wishful',
       'thinking',
       'gone',
       'gut',
       'shirt',
       'quality',
       'retailer',
       'purchase',
       'flimsy',
       'bottom',
       'like',
       'picture',
       'hang',
       'odd',
       'rumpled',
       'way',
       'top',
       'flattering',
```

```
        'though',
        'shame',
        'bottom',
        'fit',
        'nicer',
        'like',
        'product',
        'could',
        'gotten',
        'away',
        'wearing',
        'cami',
        'make',
        'qu',
        'minimally',
        'torn',
        'whether',
        'return',
        'ultimately',
        'going',
        'back',
        'knit',
        ...]
```

```
print("Lenght of positive words: ",len(positive_words))
print("Lenght of negative words: ",len(negative_words))
```

```
    Lenght of positive words:  523005
    Lenght of negative words:  118210
```

```
review_text = df_ml["text"]
```

```
all_words = " ".join(review_text)
```

```
all_words[:100]
```

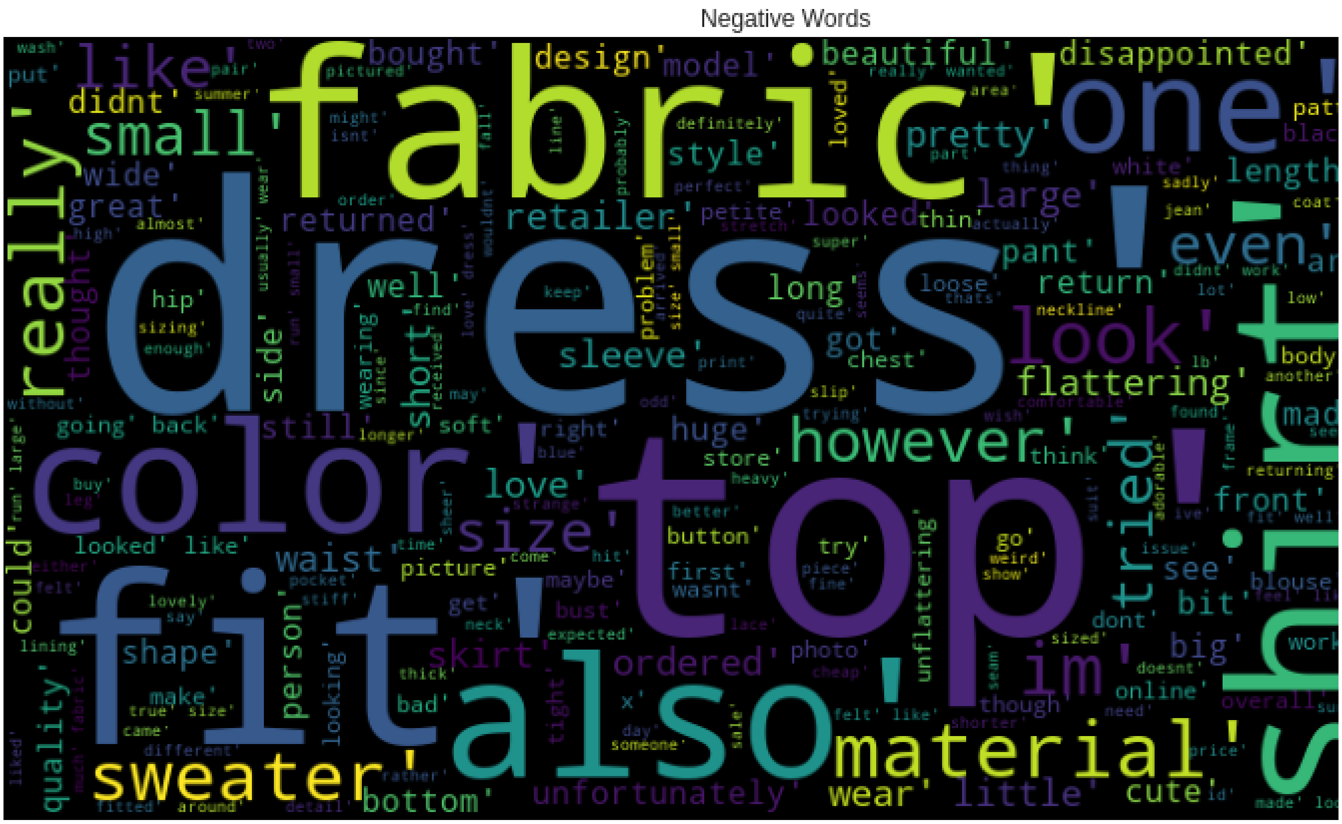
```
    'absolutely wonderful silky sexy comfortable love dress sooo pretty happened fin
```

```
wordcloud = WordCloud(width = 800, height = 400, background_color = "white", max_words
```

```
plt.figure(figsize = (14, 14))
plt.imshow(wordcloud)
plt.title('All_Words')
plt.axis("off")
plt.show()
```


```
wordcloud = WordCloud(width = 800, height = 400, background_color = "white", max_words

plt.figure(figsize = (14, 14))
plt.imshow(wordcloud)
plt.title('Positive Words')
plt.axis("off")
plt.show()
```

```
wordcloud = WordCloud(width = 800, height = 400, background_color = "black", max_words

plt.figure(figsize = (14, 14))
plt.imshow(wordcloud)
plt.title('Negative Words')
plt.axis("off")
plt.show()
```




```
counter_all = Counter(word_tokenize(all_words))
counter_all.most_common(50)
```

```
[('dress', 11352),
 ('fit', 10128),
 ('size', 9363),
 ('love', 8992),
 ('top', 8280),
 ('like', 7036),
 ('color', 6916),
 ('look', 6890),
 ('wear', 6520),
 ('great', 6101),
 ('im', 5968),
 ('would', 5014),
 ('fabric', 4862),
 ('small', 4589),
 ('really', 3924),
 ('ordered', 3835),
 ('little', 3773),
 ('perfect', 3760),
```

```
        ('one', 3704),
        ('flattering', 3485),
        ('soft', 3322),
        ('well', 3251),
        ('back', 3186),
        ('comfortable', 3047),
        ('cute', 3030),
        ('nice', 3017),
        ('bought', 2986),
        ('beautiful', 2950),
        ('bit', 2877),
        ('material', 2811),
        ('shirt', 2791),
        ('large', 2791),
        ('much', 2703),
        ('sweater', 2699),
        ('length', 2637),
        ('run', 2631),
        ('jean', 2598),
        ('also', 2583),
        ('work', 2527),
        ('petite', 2430),
        ('got', 2426),
        ('long', 2400),
        ('short', 2361),
        ('waist', 2306),
        ('quality', 2259),
        ('medium', 2233),
        ('skirt', 2220),
        ('think', 2194),
        ('pretty', 2188),
        ('even', 2166)]
```

```
X = df_ml["text"].values
y = df_ml["recommend"].map({0:1, 1:0}).values
```

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2, stratify =
```

```
from sklearn.feature_extraction.text import CountVectorizer
```

```
vectorizer = CountVectorizer()

X_train_count = vectorizer.fit_transform(X_train)
X_test_count = vectorizer.transform(X_test)
```

```
X_train_count
```

```
    <18112x10956 sparse matrix of type '<class 'numpy.int64'>'
            with 465725 stored elements in Compressed Sparse Row format>
```

```
X_test_count
```

```
<4529x10956 sparse matrix of type '<class 'numpy.int64'>'
        with 114581 stored elements in Compressed Sparse Row format>
```

```
len(X_train_count.toarray())
```

```
18112
```

```
X_train_count.toarray()
```

```
array([[0, 0, 0, ..., 0, 0, 0],
       [0, 0, 0, ..., 1, 0, 0],
       [0, 0, 0, ..., 0, 0, 0],
       ...,
       [0, 0, 0, ..., 0, 0, 0],
       [0, 0, 0, ..., 0, 0, 0],
       [0, 0, 0, ..., 0, 0, 0]])
```

```
len(X_test_count.toarray())
```

```
4529
```

```
X_test_count.toarray()
```

```
array([[0, 0, 0, ..., 0, 0, 0],
       [0, 0, 0, ..., 0, 0, 0],
       [0, 0, 0, ..., 0, 0, 0],
       ...,
       [0, 0, 0, ..., 0, 0, 0],
       [0, 0, 0, ..., 0, 0, 0],
       [0, 0, 0, ..., 0, 0, 0]])
```

```
pd.DataFrame(X_train_count.toarray(), columns = vectorizer.get_feature_names())
```

	aa	aaaaaaamazing	aaaaandidontwanttopayforshipping	aaaaannnnnnd	aaaahma
0	0	0	0	0	
1	0	0	0	0	
2	0	0	0	0	
3	0	0	0	0	
4	0	0	0	0	
...	...	...	...	...	

```
print(X_train)
```

```
['love gorgeous shade unflattering skintone make look sallow version tied dress l
 'found store last weekend thought perfect got size small plenty space usually sr
 'negative thing say color person different much coral pink rosy pink fine tad ur
 ... 'wanted love skirt good quality front loose flap exposing return'
 'absolutely love top soft comfortable perfectly flowy definitely favorite go cas
 'purchased blue version store nice royal blue navy although could worn navy thou
```

```
print(X_test)
```

```
['dont normally write review purchased dress white different size dress flaw hem
 'love style coat way fit model reality cut straight hoping darting slimmer silh
 'received dress birthday gift completely love thing wish id known mean deal brea
 ... 'super cute fitted baggy overall yesteryear love'
 'love look tee casual interesting detail make flattering wearable plain tee tri
 'absolutely beautiful quality worth agree review also sized large medium fitted
```

```
print(y_train)
```

```
[0 0 0 ... 1 0 0]
```

```
print(y_test)
```

```
[1 0 0 ... 0 0 0]
```

```
from sklearn.metrics import plot_confusion_matrix, confusion_matrix, classification_re
```

```
def eval(model, X_train, X_test):
    y_pred = model.predict(X_test)
    y_pred_train = model.predict(X_train)

    print(confusion_matrix(y_test, y_pred))
    print("Test_Set")
    print(classification_report(y_test,y_pred))
    print("Train_Set")
```

```
    print(classification_report(y_train,y_pred_train))
    plot_confusion_matrix(model, X_test, y_test, cmap="plasma")
```

Logistic Regression

```
from sklearn.linear_model import LogisticRegression

logreg_count = LogisticRegression(C = 0.1, max_iter = 1000, class_weight = 'balanced',
logreg_count.fit(X_train_count,y_train)
```

```
    LogisticRegression(C=0.1, class_weight='balanced', max_iter=1000,
                       random_state=101)
```

```
print("LogReg_Count Model")
print ("-------------------")
eval(logreg_count, X_train_count, X_test_count)
```

```
LogReg_Count Model
------------------
[[3208  501]
 [ 122  698]]
Test_Set
              precision    recall  f1-score   support

           0       0.96      0.86      0.91      3709
           1       0.58      0.85      0.69       820
```

```
import random
import pylab as pl
from sklearn.metrics import precision_recall_curve
from sklearn.metrics import auc


from yellowbrick.classifier import PrecisionRecallCurve

viz = PrecisionRecallCurve(
      LogisticRegression(C = 0.1, max_iter = 1000, class_weight= "balanced", random_st
      classes = logreg_count.classes_,
      per_class = True,
      cmap = "Set1")

fig, ax = plt.subplots(figsize = (10, 6))
ax.set_facecolor('#eafff5')

viz.fit(X_train_count,y_train)
viz.score(X_test_count, y_test)
viz.show();
```

```
y_pred = logreg_count.predict(X_test_count)
log_count_rec = recall_score(y_test, y_pred, pos_label = 0, average = None)
log_count_f1 = f1_score(y_test, y_pred, pos_label = 0, average = None)
log_AP = viz.score_
```

```
print("viz.score_       : ", viz.score_)
print("LogReg_Count_rec : ", log_count_rec)
print("LogReg_Count_f1  : ", log_count_f1)
print("LogReg_Count_AP  : ", log_AP)
```

```
viz.score_       :  0.7318428079050375
LogReg_Count_rec :  [0.86492316 0.85121951]
LogReg_Count_f1  :  [0.91149311 0.6914314 ]
LogReg_Count_AP  :  0.7318428079050375
```

```
from sklearn.metrics import make_scorer
from sklearn.model_selection import cross_val_score

custom_scorer = {'accuracy': make_scorer(accuracy_score),
                 'precision-0': make_scorer(precision_score, pos_label = 0),
                 'recall-0': make_scorer(recall_score, pos_label = 0),
                 'f1-0': make_scorer(f1_score, pos_label = 0),
                 'precision-1': make_scorer(precision_score, pos_label = 1),
                 'recall-1': make_scorer(recall_score, pos_label = 1),
                 'f1-1': make_scorer(f1_score, pos_label = 1)
                 }

for i, j in custom_scorer.items():
    model = LogisticRegression(C = 0.1, max_iter = 1000, class_weight = "balanced", ra
    scores = cross_val_score(model, X_train_count, y_train, cv = 10, scoring = j).mean
    if i == "recall-0":
        log_count_rec = scores
    elif i == "f1-0":
        log_count_f1 = scores
    print(f" {i:20} score for LogReg_Count : {scores}\n")
```

```
 accuracy             score for LogReg_Count : 0.8637374860278675

 precision-0          score for LogReg_Count : 0.9571851639346928

 recall-0             score for LogReg_Count : 0.8726318310120267

 f1-0                 score for LogReg_Count : 0.9129407323973634

 precision-1          score for LogReg_Count : 0.5887900060147659

 recall-1             score for LogReg_Count : 0.8235349173400548

 f1-1                 score for LogReg_Count : 0.6865592567745237
```

```
LogReg_Count_AP = viz.score_
LogReg_Count_AP
```

```
0.7318428079050375
```

NaiveBayes

```
from sklearn.naive_bayes import MultinomialNB
```

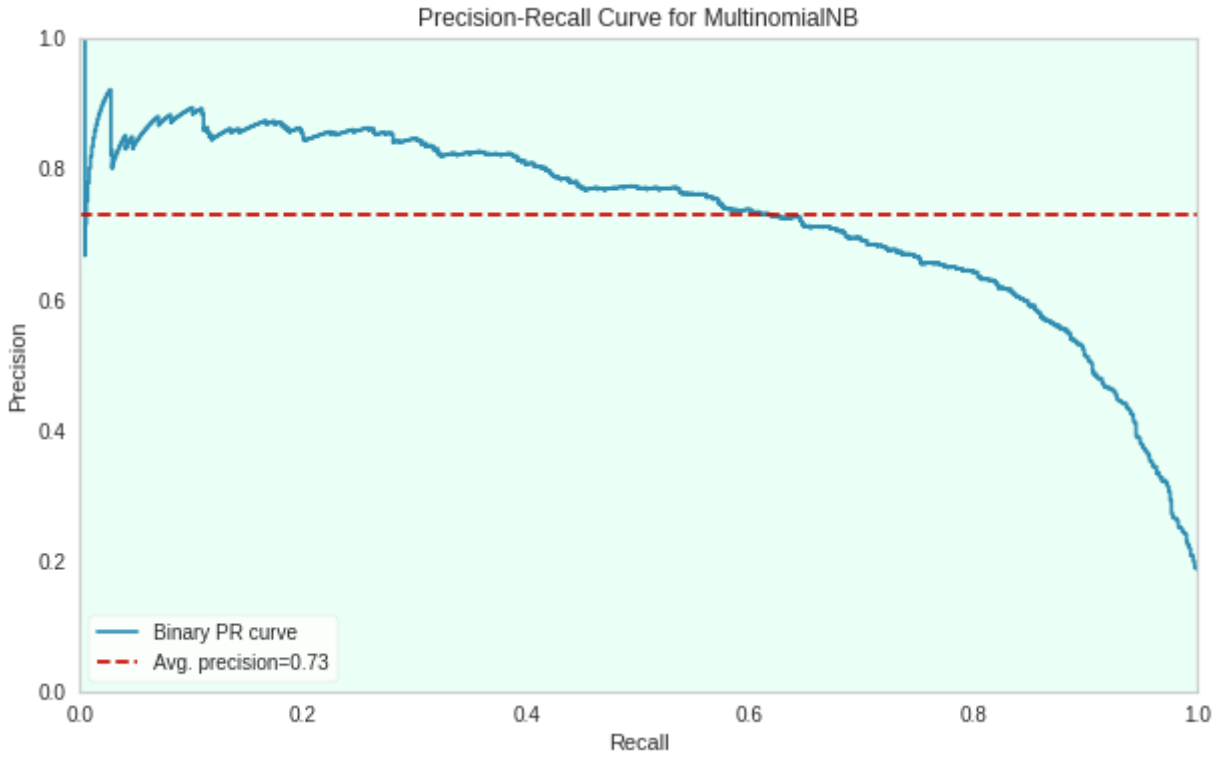
```
nbmulti_count = MultinomialNB()
nbmulti_count.fit(X_train_count,y_train)
```

```
MultinomialNB()
```

```
print("NBMulti_Count Model")
print("--------------------")
eval(nbmulti_count, X_train_count, X_test_count)
```

```
NBMulti_Count Model
-------------------
[[3466  243]
 [ 258  562]]
Test_Set
              precision    recall  f1-score   support

           0       0.93      0.93      0.93      3709
           1       0.70      0.69      0.69       820

    accuracy                           0.89      4529
   macro avg       0.81      0.81      0.81      4529
weighted avg       0.89      0.89      0.89      4529

Train_Set
```

```
from yellowbrick.classifier import PrecisionRecallCurve

viz = PrecisionRecallCurve(
      MultinomialNB(),
      classes = nbmulti_count.classes_,
      per_class = True,
      cmap = "Set1")

fig, ax = plt.subplots(figsize = (10, 6))
ax.set_facecolor('#eafff5')

viz.fit(X_train_count,y_train)
viz.score(X_test_count, y_test)
viz.show();
```




```
y_pred = nbmulti_count.predict(X_test_count)
```

```
y_pred = nbmulti_count.predict(X_test_count)
nb_multi_count_rec = recall_score(y_test, y_pred, pos_label = 0, average = None)
nb_multi_count_f1 = f1_score(y_test, y_pred, pos_label = 0, average = None)
nb_multi_count_AP = viz.score_


print("viz.score_         : ", viz.score_)
print("NBMulti_Count_rec : ", nb_multi_count_rec)
print("NBMulti_Count_f1  : ", nb_multi_count_f1)
print("NBMulti_Count_AP  : ", nb_multi_count_AP)
```

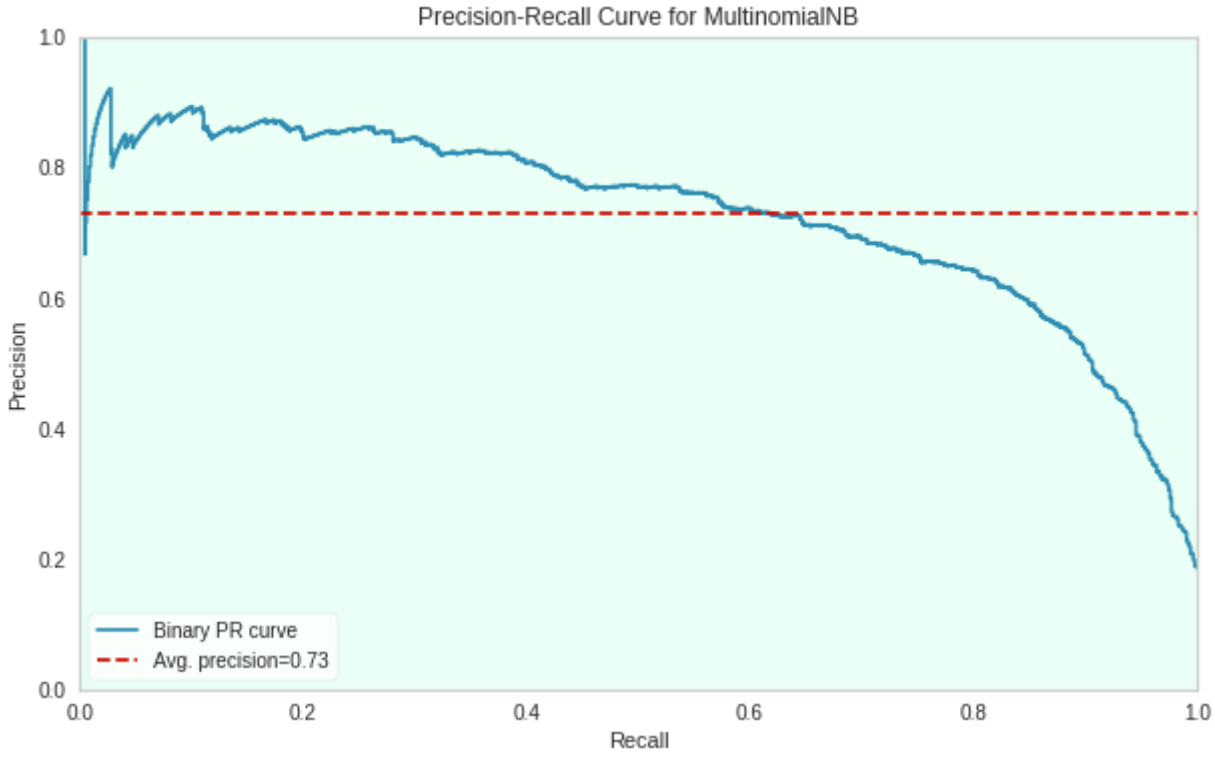
```
viz.score_         :  0.7282257898302862
NBMulti_Count_rec :  [0.93448369 0.68536585]
NBMulti_Count_f1  :  [0.93259787 0.69169231]
NBMulti_Count_AP  :  0.7282257898302862
```

```
custom_scorer = {'accuracy': make_scorer(accuracy_score),
                 'precision-0': make_scorer(precision_score, pos_label=0),
                 'recall-0': make_scorer(recall_score, pos_label=0),
                 'f1-0': make_scorer(f1_score, pos_label=0),
                 'precision-1': make_scorer(precision_score, pos_label=1),
                 'recall-1': make_scorer(recall_score, pos_label=1),
                 'f1-1': make_scorer(f1_score, pos_label=1)
                 }

for i, j in custom_scorer.items():
    model = MultinomialNB()
    scores = cross_val_score(model, X_train_count, y_train, cv = 10, scoring = j).mean
    if i == "recall-1":
        nbm_count_rec = scores
    elif i == "f1-1":
        nbm_count_f1 = scores
    print(f" {i:20} score for NBMulti_Count : {scores}\n")
```

```
accuracy             score for NBMulti_Count : 0.881791766772349

precision-0          score for NBMulti_Count : 0.929266610342754

recall-0             score for NBMulti_Count : 0.9261684536153677

f1-0                 score for NBMulti_Count : 0.9277051344427043

precision-1          score for NBMulti_Count : 0.6711258849457677

recall-1             score for NBMulti_Count : 0.6811939357995405

f1-1                 score for NBMulti_Count : 0.6759818179703109
```

```
from yellowbrick.classifier import PrecisionRecallCurve

viz = PrecisionRecallCurve(
```

```
    MultinomialNB(),
    classes = nbmulti_count.classes_,
    per_class = True,
    cmap = "Set1"
)

fig, ax = plt.subplots(figsize = (10, 6))
ax.set_facecolor('#eafff5')

viz.fit(X_train_count,y_train)
viz.score(X_test_count, y_test)
viz.show();
```




```
NBMulti_Count_AP = viz.score_
NBMulti_Count_AP
```

```
    0.7282257898302862
```

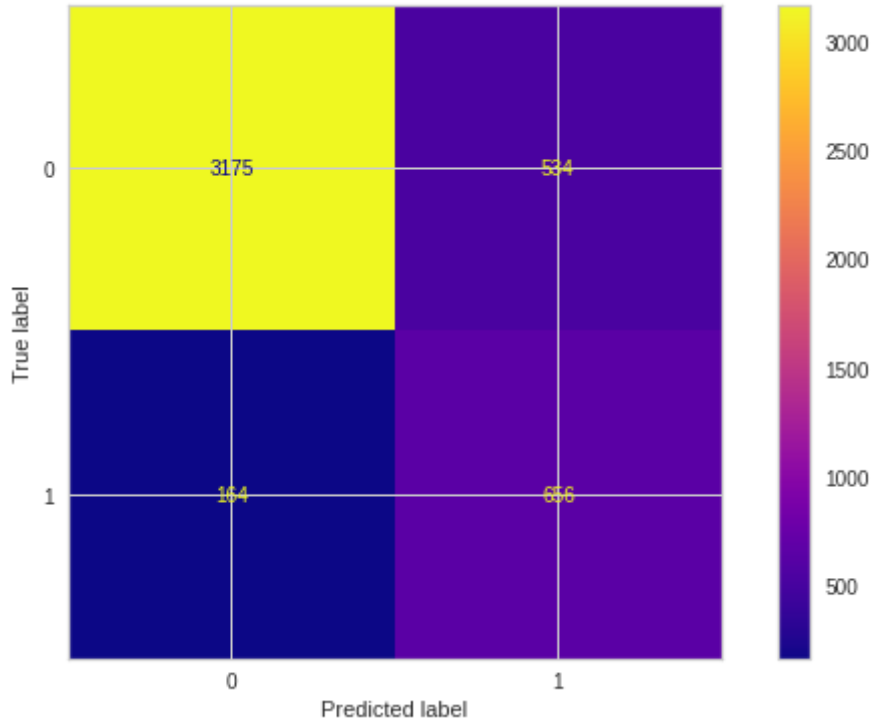
RandomForest

```
from sklearn.ensemble import RandomForestClassifier

rf_count = RandomForestClassifier(n_estimators = 200, max_depth = 11, class_weight = '
rf_count.fit(X_train_count, y_train)
```

```
    RandomForestClassifier(class_weight='balanced', max_depth=11, n_estimators=200,
                           n_jobs=-1, random_state=101)
```

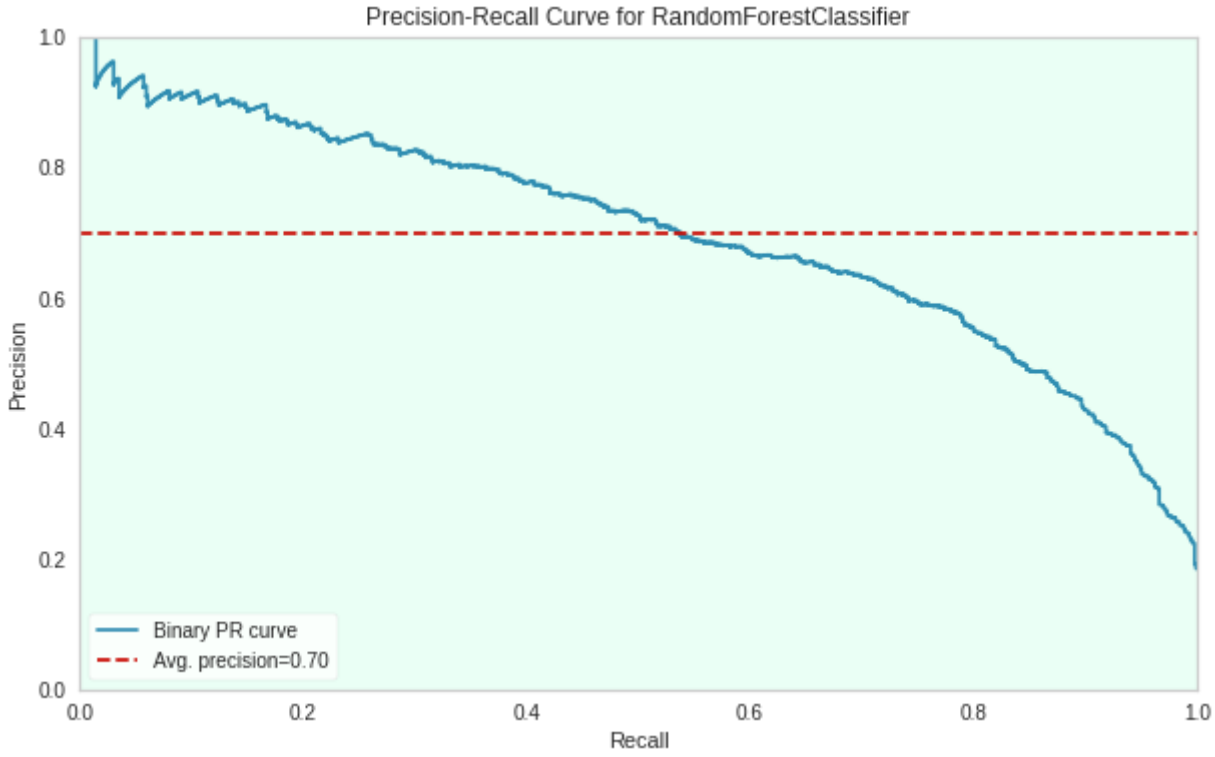
```
print("RF_Count Model")
print("--------------")
eval(rf_count, X_train_count, X_test_count)
```

```
RF_Count Model
--------------
[[3175  534]
 [ 164  656]]
Test_Set
              precision    recall  f1-score   support

           0       0.95      0.86      0.90      3709
           1       0.55      0.80      0.65       820

    accuracy                           0.85      4529
   macro avg       0.75      0.83      0.78      4529
weighted avg       0.88      0.85      0.86      4529

Train_Set
              precision    recall  f1-score   support

           0       0.97      0.88      0.93     14831
           1       0.63      0.89      0.74      3281

    accuracy                           0.88     18112
   macro avg       0.80      0.89      0.83     18112
weighted avg       0.91      0.88      0.89     18112
```




```
viz = PrecisionRecallCurve(
      RandomForestClassifier(n_estimators = 200, max_depth = 11, class_weight = "balar
      classes = rf_count.classes_,
```

```
        per_class = True,
        cmap = "Set1")

fig, ax = plt.subplots(figsize=(10, 6))
ax.set_facecolor('#eafff5')

viz.fit(X_train_count,y_train)
viz.score(X_test_count, y_test)
viz.show();
```




```
y_pred = rf_count.predict(X_test_count)
rf_count_rec = recall_score(y_test, y_pred, pos_label = 0, average = None)
rf_count_f1 = f1_score(y_test, y_pred, pos_label = 0, average = None)
rf_count_AP = viz.score_


print("viz.score_   : ", viz.score_)
print("RF_Count_rec : ", rf_count_rec)
print("RF_Count_f1  : ", rf_count_f1)
print("RF_Count_AP  : ", rf_count_AP)
```

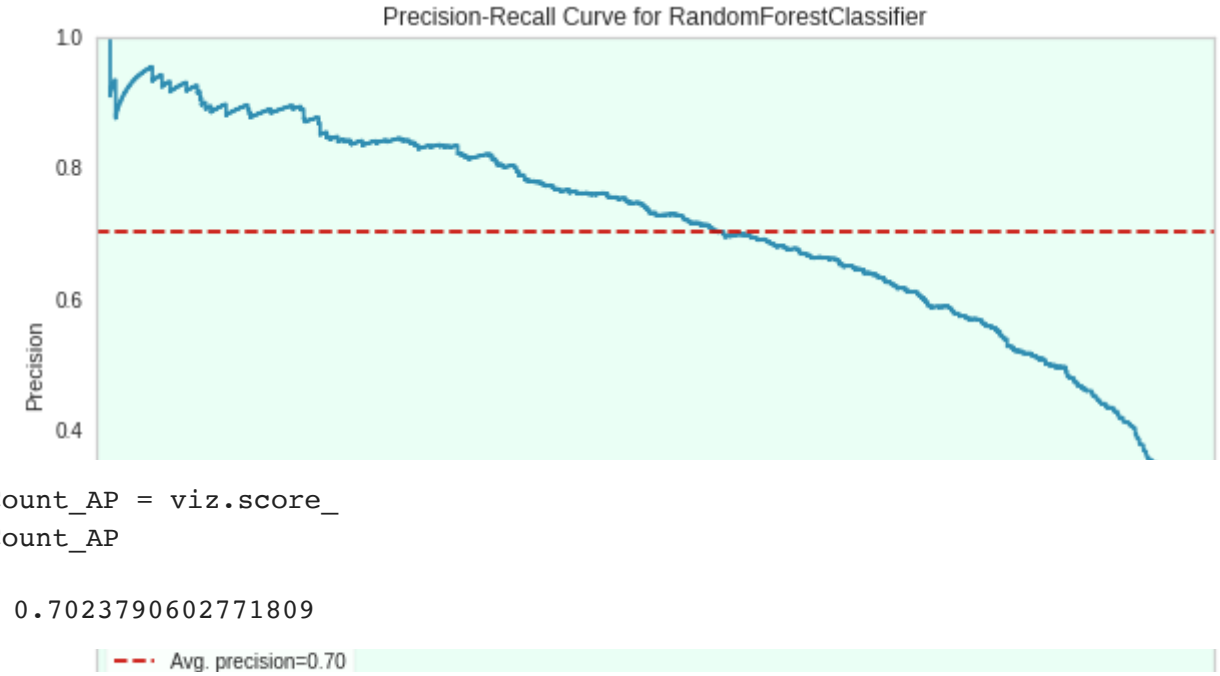
```
    viz.score_   :  0.6985344026437313
    RF_Count_rec :  [0.85602588 0.8       ]
    RF_Count_f1  :  [0.90096481 0.65273632]
    RF_Count_AP  :  0.6985344026437313
```

```
custom_scorer = {'accuracy': make_scorer(accuracy_score),
                 'precision-0': make_scorer(precision_score, pos_label = 0),
                 'recall-0': make_scorer(recall_score, pos_label = 0),
```

```
                  'f1-0': make_scorer(f1_score, pos_label = 0),
                  'precision-1': make_scorer(precision_score, pos_label = 1),
                  'recall-1': make_scorer(recall_score, pos_label = 1),
                  'f1-1': make_scorer(f1_score, pos_label = 1)
                  }

for i, j in custom_scorer.items():
    model = RandomForestClassifier(n_estimators = 200, max_depth = 11, class_weight =
    scores = cross_val_score(model, X_train_count, y_train, cv = 10, scoring = j).mear
    if i == "recall-1":
        rf_count_rec = scores
    elif i == "f1-1":
        rf_count_f1 = scores
    print(f" {i:20} score for RF_Count : {scores}\n")
```

```
 accuracy             score for RF_Count : 0.8500441562050896

 precision-0          score for RF_Count : 0.9484565157823012

 recall-0             score for RF_Count : 0.8638655889842293

 f1-0                 score for RF_Count : 0.9041461483119981

 precision-1          score for RF_Count : 0.5617179066877422

 recall-1             score for RF_Count : 0.7875648676699532

 f1-1                 score for RF_Count : 0.6554933545933405
```

```
viz = PrecisionRecallCurve(
      RandomForestClassifier(200, max_depth = 12, random_state = 42, n_jobs = -1, clas
      classes = rf_count.classes_,
      per_class = True,
      cmap = "Set1")

fig, ax = plt.subplots(figsize=(10, 6))
ax.set_facecolor('#eafff5')

viz.fit(X_train_count,y_train)
viz.score(X_test_count, y_test)
viz.show();
```




```
RF_Count_AP = viz.score_
RF_Count_AP
```

```
0.7023790602771809
```

```
compare = pd.DataFrame({"Model": ["NaiveBayes(Multi)_Count","LogReg_Count", "Random Fo
                        "F1_Score": [nbm_count_f1, log_count_f1, rf_count_f1],
                        "Recall_Score": [nbm_count_rec, log_count_rec, rf_count_rec],
                        "Average_Precision_Score": [NBMulti_Count_AP, LogReg_Count_AP,
```

```
compare = compare.sort_values(by="Recall_Score", ascending=True)
compare
```

	Model	F1_Score	Recall_Score	Average_Precision_Score
0	NaiveBayes(Multi)_Count	0.676	0.681	0.728
2	Random Forest_Count	0.655	0.788	0.702
1	LogReg_Count	0.913	0.873	0.732

```
compare = compare.sort_values(by="F1_Score", ascending=True)
compare
```

	Model	F1_Score	Recall_Score	Average_Precision_Score
2	Random Forest_Count	0.655	0.788	0.702
0	NaiveBayes(Multi)_Count	0.676	0.681	0.728
1	LogReg_Count	0.913	0.873	0.732

```
compare = compare.sort_values(by="Average_Precision_Score", ascending=True)
```

```
compare
```

	Model	F1_Score	Recall_Score	Average_Precision_Score
2	Random Forest_Count	0.655	0.788	0.702
0	NaiveBayes(Multi)_Count	0.676	0.681	0.728
1	LogReg_Count	0.913	0.873	0.732