Amazon Fine Food Reviews Analysis

Data Source: https://www.kaggle.com/snap/amazon-fine-food-reviews (https://www.kaggle.com/snap/amazon-fine-food-reviews)

EDA: https://nycdatascience.com/blog/student-works/amazon-fine-foods-visualization/ (https://nycdatascience.com/blog/student-works/amazon-fine-foods-visualization/)

The Amazon Fine Food Reviews dataset consists of reviews of fine foods from Amazon.

Number of reviews: 568,454
Number of users: 256,059
Number of products: 74,258
Timespan: Oct 1999 - Oct 2012
Number of Attributes/Columns in data: 10

Attribute Information:

1. Id
2. ProductId - unique identifier for the product
3. UserId - unqiue identifier for the user
4. ProfileName
5. HelpfulnessNumerator - number of users who found the review helpful
6. HelpfulnessDenominator - number of users who indicated whether they found the review helpful or not
7. Score - rating between 1 and 5
8. Time - timestamp for the review
9. Summary - brief summary of the review
10. Text - text of the review

Objective:

Given a review, determine whether the review is positive (rating of 4 or 5) or negative (rating of 1 or 2).

[Q] How to determine if a review is positive or negative?

[Ans] We could use Score/Rating. A rating of 4 or 5 can be cosnidered as a positive review. A rating of 1 or 2 can be considered as negative one. A review of rating 3 is considered nuetral and such reviews are ignored from our analysis. This is an approximate and proxy way of determining the polarity (positivity/negativity) of a review.

[1]. Reading Data

[1.1] Loading the data

The dataset is available in two forms

1. .csv file
2. SQLite Database

In order to load the data, We have used the SQLITE dataset as it is easier to query the data and visualise the data efficiently.

Here as we only want to get the global sentiment of the recommendations (positive or negative), we will purposefully ignore all Scores equal to 3. If the score is above 3, then the recommendation wil be set to "positive". Otherwise, it will be set to "negative".

In [0]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")


import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os
```

In [5]:

```
from google.colab import drive
drive.mount('/content/gdrive')
```

```
Drive already mounted at /content/gdrive; to attempt to forcibly remount, call drive.mount("/content/gdrive", f
orce_remount=True).
```

In [6]:

```python
# using SQLite Table to read data.
con = sqlite3.connect('gdrive/My Drive/database.sqlite')

# filtering only positive and negative reviews i.e.
# not taking into consideration those reviews with Score=3
# SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000, will give top 500000 data points
# you can change the number to any other number based on your computing power

# filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000""", con)
# for tsne assignment you can take 5k data points

filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 """, con)

# Give reviews with Score>3 a positive rating(1), and reviews with a score<3 a negative rating(0).
def partition(x):
    if x < 3:
        return 0
    return 1

#changing reviews with score less than 3 to be positive and vice-versa
actualScore = filtered_data['Score']
positiveNegative = actualScore.map(partition)
filtered_data['Score'] = positiveNegative
print("Number of data points in our data", filtered_data.shape)
filtered_data.head(3)
```

```
Number of data points in our data (525814, 10)
```

Out[6]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary	
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1	1	1303862400	Good Quality Dog Food	I sev . c
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0	0	1346976000	Not as Advertised	P a labe . Pe

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary	
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1	1	1219017600	"Delight" says it all	Th con th arc

In [0]:

```
display = pd.read_sql_query("""
SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
FROM Reviews
GROUP BY UserId
HAVING COUNT(*)>1
""", con)
```

In [8]:

```
print(display.shape)
display.head()
```

```
(80668, 7)
```

Out[8]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK when considering the price...	2
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recurring extreme muscle spasms, u...	3
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horrible and unfortunately not ...	2
3	#oc-R11O5J5ZVQE25C	B005HG9ET0	Penguin Chick	1346889600	5	This will be the bottle that you grab from the...	3
4	#oc-R12KPBODL2B5ZD	B007OSBE1U	Christopher P. Presta	1348617600	1	I didnt like this coffee. Instead of telling y...	2

In [9]:

```
display[display['UserId']=='AZY10LLTJ71NX']
```

Out[9]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
80638	AZY10LLTJ71NX	B006P7E5ZI	undertheshrine "undertheshrine"	1334707200	5	I was recommended to try green tea extract to ...	5

In [10]:

```
display['COUNT(*)'].sum()
```

Out[10]:

```
393063
```

[2] Exploratory Data Analysis

[2.1] Data Cleaning: Deduplication

It is observed (as shown in the table below) that the reviews data had many duplicate entries. Hence it was necessary to remove duplicates in order to get unbiased results for the analysis of the data. Following is an example:

In [11]:

```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND UserId="AR5J8UI46CURR"
ORDER BY ProductID
""", con)
display.head()
```

Out[11]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACKER QUADRATINI VANILLA WAFERS
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACKER QUADRATINI VANILLA WAFERS
2	138277	B000HDOPYM	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACKER QUADRATINI VANILLA WAFERS
3	73791	B000HDOPZG	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACKER QUADRATINI VANILLA WAFERS
4	155049	B000PAQ75C	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACKER QUADRATINI VANILLA WAFERS

As it can be seen above that same user has multiple reviews with same values for HelpfulnessNumerator, HelpfulnessDenominator, Score, Time, Summary and Text and on doing analysis it was found that

ProductId=B000HDOPZG was Loacker Quadratini Vanilla Wafer Cookies, 8.82-Ounce Packages (Pack of 8)

ProductId=B000HDL1RQ was Loacker Quadratini Lemon Wafer Cookies, 8.82-Ounce Packages (Pack of 8) and so on

It was inferred after analysis that reviews with same parameters other than ProductId belonged to the same product just having different flavour or quantity. Hence in order to reduce redundancy it was decided to eliminate the rows having same parameters.

The method used for the same was that we first sort the data according to ProductId and then just keep the first similar product review and delelte the others. for eg. in the above just the review for ProductId=B000HDL1RQ remains. This method ensures that there is only one representative for each product and deduplication without sorting would lead to possibility of different representatives still existing for the same product.

In [0]:

```
#Sorting data according to ProductId in ascending order
sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True, inplace=False, kind='quicksort',
```

In [13]:

```
#Deduplication of entries
final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep='first', inplace=False
final.shape
```

Out[13]:

```
(364173, 10)
```

In [14]:

```
#Checking to see how much % of data still remains
(final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

Out[14]:

```
69.25890143662969
```

Observation:- It was also seen that in two rows given below the value of HelpfulnessNumerator is greater than HelpfulnessDenominator which is not practically possible hence these two rows too are removed from calcualtions

In [15]:

```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND Id=44737 OR Id=64422
ORDER BY ProductID
""", con)

display.head()
```

Out[15]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary	
0	64422	B000MIDROQ	A161DK06JJMCYF	J. E. Stephens "Jeanne"	3	1	5	1224892800	Bought This for My Son at College	sp h
1	44737	B001EQ55RW	A2V0I904FH7ABY	Ram	3	2	4	1212883200	Pure cocoa taste with crunchy almonds inside	a fi

In [0]:

```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

Taking 30k datapoints

In [17]:

```
#Before starting the next phase of preprocessing lets see the number of entries left
final = final.sample(30000)

#How many positive and negative reviews are present in our dataset?
final['Score'].value_counts()
```

Out[17]:

```
1    25266
0     4734
Name: Score, dtype: int64
```

In [18]:

```
final = final.sort_values('Time',ascending = True)
final
```

Out[18]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Scc
138683	150501	0006641040	AJ46FKXOVC7NR	Nicholas A Mesiano	2	2	
138000	149768	B00004S1C5	A7P76IGRZZBFJ	E. Thompson "Soooooper Genius"	18	18	
346033	374335	B00004CI84	A3L5V40F14R2GP	AARON	0	0	
346031	374333	B00004CI84	A1CZICCYP2M5PX	Christian Pelchat	0	0	
28086	30629	B00008RCMI	A19E94CF5O1LY7	Andrew Arnold	0	0	

[3] Preprocessing

[3.1]. Preprocessing Review Text

Now that we have finished deduplication our data requires some preprocessing before we go on further with analysis and making the prediction model.

Hence in the Preprocessing phase we do the following in the order below:-

1. Begin by removing the html tags
2. Remove any punctuations or limited set of special characters like , or . or # etc.
3. Check if the word is made up of english letters and is not alpha-numeric
4. Check to see if the length of the word is greater than 2 (as it was researched that there is no adjective in 2-letters)
5. Convert the word to lowercase
6. Remove Stopwords

7. Finally Snowball Stemming the word (it was obsereved to be better than Porter Stemming)

After which we collect the words used to describe positive and negative reviews

In [19]:

```python
# printing some random reviews
sent_0 = final['Text'].values[0]
print(sent_0)
print("="*50)

sent_1000 = final['Text'].values[1000]
print(sent_1000)
print("="*50)

sent_1500 = final['Text'].values[1500]
print(sent_1500)
print("="*50)

sent_4900 = final['Text'].values[4900]
print(sent_4900)
print("="*50)
```

```
I can remember seeing the show when it aired on television years ago, when I was a child.  My sister later boug
ht me the LP (which I have to this day,  I'm thirty something).I used this series of books &amp; songs when I d
id my  student teaching for preschoolers &amp; turned the whole school on to it.  I am now purchasing it on CD,
along with the books for my children 5 &amp;  2.  The tradition lives on!
==================================================
I love this product.  All I care about is my health, (breast cancer survivor). Yes, of course I have bits in be
tween my teeth afterwards, so what. I have already recommended this product to two friends.  It does not bloat
me out, it is zapped in a blender with almond milk, a banana, goji berries and a few strawberries and a bit of
pineapple.<br /><br />I know that I am getting a good and healthy breakfast, plus I have lost a few pounds in t
he last two weeks as well.  I also have the hemp seeds and oil on a salad at lunchtime.<br /><br />Thank you Nu
tiva!
==================================================
We are always on the lookout for a good gluten free pasta. This one cooks up al dente very nicely, and my son w
ho is quite selective, likes it. Would make a good pasta for pasta salad since it can hold up to sauces well an
d to reheating, too.
==================================================
This fungicide was very effective on my tomatoe plants .I thought they were dead, now they are green and lush w
ith blossoms...FANTASTIC.
==================================================
```

In [20]:

```python
# remove urls from text python: https://stackoverflow.com/a/40823105/4084039
sent_0 = re.sub(r"http\S+", "", sent_0)
sent_1000 = re.sub(r"http\S+", "", sent_1000)
sent_150 = re.sub(r"http\S+", "", sent_1500)
sent_4900 = re.sub(r"http\S+", "", sent_4900)

print(sent_0)
```

```
I can remember seeing the show when it aired on television years ago, when I was a child.  My sister later boug
ht me the LP (which I have to this day,  I'm thirty something).I used this series of books &amp; songs when I d
id my  student teaching for preschoolers &amp; turned the whole school on to it.  I am now purchasing it on CD,
along with the books for my children 5 &amp;  2.  The tradition lives on!
```

In [21]:

```python
# https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all-tags-from-an-element
from bs4 import BeautifulSoup

soup = BeautifulSoup(sent_0, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1000, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1500, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_4900, 'lxml')
text = soup.get_text()
print(text)
```

```
I can remember seeing the show when it aired on television years ago, when I was a child.  My sister later boug
ht me the LP (which I have to this day,  I'm thirty something).I used this series of books & songs when I did m
y  student teaching for preschoolers & turned the whole school on to it.  I am now purchasing it on CD, along w
ith the books for my children 5 &  2.  The tradition lives on!
==================================================
I love this product.  All I care about is my health, (breast cancer survivor). Yes, of course I have bits in be
tween my teeth afterwards, so what. I have already recommended this product to two friends.  It does not bloat
me out, it is zapped in a blender with almond milk, a banana, goji berries and a few strawberries and a bit of
pineapple.I know that I am getting a good and healthy breakfast, plus I have lost a few pounds in the last two
weeks as well.  I also have the hemp seeds and oil on a salad at lunchtime.Thank you Nutiva!
==================================================
We are always on the lookout for a good gluten free pasta. This one cooks up al dente very nicely, and my son w
ho is quite selective, likes it. Would make a good pasta for pasta salad since it can hold up to sauces well an
d to reheating, too.
==================================================
This fungicide was very effective on my tomatoe plants .I thought they were dead, now they are green and lush w
ith blossoms...FANTASTIC.
```

In [0]:

```python
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [23]:

```python
sent_1500 = decontracted(sent_1500)
print(sent_1500)
print("="*50)
```

```
We are always on the lookout for a good gluten free pasta. This one cooks up al dente very nicely, and my son w
ho is quite selective, likes it. Would make a good pasta for pasta salad since it can hold up to sauces well an
d to reheating, too.
==================================================
```

In [24]:

```python
#remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
print(sent_0)
```

```
I can remember seeing the show when it aired on television years ago, when I was a child.  My sister later boug
ht me the LP (which I have to this day,  I'm thirty something).I used this series of books &amp; songs when I d
id my  student teaching for preschoolers &amp; turned the whole school on to it.  I am now purchasing it on CD,
along with the books for my children  &amp;    The tradition lives on!
```

In [25]:

```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent_1500 = re.sub('[^A-Za-z0-9]+', ' ', sent_1500)
print(sent_1500)
```

```
We are always on the lookout for a good gluten free pasta This one cooks up al dente very nicely and my son who
is quite selective likes it Would make a good pasta for pasta salad since it can hold up to sauces well and to
reheating too
```

In [0]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
# <br /><br /> ==> after the above steps, we are getting "br br"
# we are including them into stop words list
# instead of <br /> if we have <br/> these tags would have revmoved in the 1st step

stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'their'
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 'tho
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do', '
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while', '
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before',
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again'
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'f
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm', '
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't",
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'mus
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'were
            'won', "won't", 'wouldn', "wouldn't"])
```

In [27]:

```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_reviews = []
# tqdm is for printing the status bar
for sentance in tqdm(final['Text'].values):
    sentance = re.sub(r"http\S+", "", sentance)
    sentance = BeautifulSoup(sentance, 'lxml').get_text()
    sentance = decontracted(sentance)
    sentance = re.sub("\S*\d\S*", "", sentance).strip()
    sentance = re.sub('[^A-Za-z]+', ' ', sentance)
    # https://gist.github.com/sebleier/554280
    sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopwords)
    preprocessed_reviews.append(sentance.strip())
```

```
100%|██████████| 30000/30000 [00:09<00:00, 3013.58it/s]
```

In [28]:

```
preprocessed_reviews[1500]
```

Out[28]:

```
'always lookout good gluten free pasta one cooks al dente nicely son quite selective likes would make good past
a pasta salad since hold sauces well reheating'
```

Splitting the data

In [29]:

```
from sklearn.model_selection import train_test_split

X_train,X_test,Y_train,Y_test = train_test_split(preprocessed_reviews,final['Score'],test_size = 0.3,random_
print('AFter splitting:\n')
print('Size of training data is:',len(X_train))
print('Size of test data is:',len(X_test))
```

```
AFter splitting:

Size of training data is: 21000
Size of test data is: 9000
```

In [30]:

```
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits = 10)
print(tscv)
```

```
TimeSeriesSplit(max_train_size=None, n_splits=10)
```

In [31]:

```
for train,cv in tscv.split(X_train):
    print('SIZE OF TRAINING SET:',train.shape,'SIZE OF VALIDATION SET',cv.shape)
```

```
SIZE OF TRAINING SET: (1910,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (3819,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (5728,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (7637,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (9546,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (11455,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (13364,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (15273,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (17182,) SIZE OF VALIDATION SET (1909,)
SIZE OF TRAINING SET: (19091,) SIZE OF VALIDATION SET (1909,)
```

[4] Featurization

BAG OF WORDS

In [32]:

```python
bow_vect = CountVectorizer(min_df = 10,max_features = 500)
bow_vect.fit(X_train)

train_bow = bow_vect.transform(X_train)
test_bow = bow_vect.transform(X_test)

print('AFTER VECTORIZATION :\n')
print('training set:',train_bow.shape)
print('test set:',test_bow.shape)
```

```
AFTER VECTORIZATION :

training set: (21000, 500)
test set: (9000, 500)
```

TFIDF

In [0]:

```python
tfidf_vect = TfidfVectorizer(ngram_range = (1,2),max_df = 10,max_features = 500)
tfidf_vect.fit(X_train)

train_tfidf = tfidf_vect.transform(X_train)
test_tfidf = tfidf_vect.transform(X_test)
```

WORD 2 VECTOR

Average Word 2 Vector

In [0]:

```python
s_train = []
for sent in X_train:
    s_train.append(sent.split())
#preparing the training data for  word to vector vectorization

s_test = []
for sent in X_test:
    s_test.append(sent.split())
#preparing the test data for word to vector fatorization
```

In [34]:

```python
w2v_model=Word2Vec(s_train,min_count=5,size=50, workers=4)# min_count = 5 considers only words that occured

w2v_words = list(w2v_model.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words))

```

```
number of words that occured minimum 5 times  9060
```

In [59]:

```python
#Average word2vec
#computing average word to vector for training data

train_avgw2v = [] # the avg-w2v for each sentence/review is stored in this list
for sent in tqdm(s_train):
    sent_vec = np.zeros(50)
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: #
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    train_avgw2v.append(sent_vec)

print(len(train_avgw2v))#number of datapoints in training set
```

```
100%|██████████| 21000/21000 [00:27<00:00, 776.18it/s]

21000
```

In [60]:

```
#computing average word to vector for test data

test_avgw2v = [] # the avg-w2v for each sentence/review is stored in this list
for sent in tqdm(s_test):
    sent_vec = np.zeros(50)
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: #
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    test_avgw2v.append(sent_vec)

print(len(test_avgw2v))#number of datapoints in test set
```

```
100%|██████████| 9000/9000 [00:12<00:00, 742.04it/s]

9000
```

In [0]:

```

```

TFIDF Word 2 Vector

In [0]:

```
vect = TfidfVectorizer(ngram_range = (1,2),min_df = 10,max_features = 500)#initializing the tfidf vectorizer

tf_idf = vect.fit_transform(X_train)#fitting the training data
dictionary = dict(zip(vect.get_feature_names(), list(vect.idf_)))#zipping both of the feature names and vect
```

In [0]:

```

tfidf_feat = vect.get_feature_names()
```

In [37]:

```
train_tfidfw2v = []; # the tfidf-w2v for each sentence/review in training set is stored in this list
row=0;
for sent in tqdm(s_train): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    train_tfidfw2v.append(sent_vec)
    row += 1
print(len(train_tfidfw2v))
```

```
100%|██████████| 21000/21000 [00:35<00:00, 597.39it/s]

21000
```

In [38]:

```python
test_tfidfw2v = []; # the tfidf-w2v for each sentence/review in test set is stored in this list
row=0;
for sent in tqdm(s_test): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    test_tfidfw2v.append(sent_vec)
    row += 1

print(len(test_tfidfw2v))

```

```
100%|██████████| 9000/9000 [00:15<00:00, 577.08it/s]

9000
```

1. **Apply SVM on these feature sets**

    - SET 1:Review text, preprocessed one converted into vectors using (BOW)
    - SET 2:Review text, preprocessed one converted into vectors using (TFIDF)
    - SET 3:Review text, preprocessed one converted into vectors using (AVG W2v)
    - SET 4:Review text, preprocessed one converted into vectors using (TFIDF W2v)

2. **Procedure**

    - You need to work with 2 versions of SVM
        - Linear kernel
        - RBF kernel
    - When you are working with linear kernel, use SGDClassifier' with hinge loss because it is computationally less expensive.
    - When you are working with 'SGDClassifier' with hinge loss and trying to find the AUC score, you would have to use CalibratedClassifierCV (https://scikit-learn.org/stable/modules/generated/sklearn.calibration.CalibratedClassifierCV.html)

- Similarly, like kdtree of knn, when you are working with RBF kernel it's better to reduce the number of dimensions. You can put min_df = 10, max_features = 500 and consider a sample size of 40k points.

3. **Hyper paramter tuning (find best alpha in range [10^-4 to 10^4], and the best penalty among 'l1', 'l2')**

   - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
   - Find the best hyper paramter using k-fold cross validation or simple cross validation data
   - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

4. **Feature importance**

   - When you are working on the linear kernel with BOW or TFIDF please print the top 10 best features for each of the positive and negative classes.

5. **Feature engineering**

   - To increase the performance of your model, you can also experiment with with feature engineering like :
     - Taking length of reviews as another feature.
     - Considering some features from review summary as well.

6. **Representation of results**

   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure.
   - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
   - Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points. Please visualize your confusion matrices using seaborn heatmaps.

     (https://seaborn.pydata.org/generated/seaborn.heatmap.html)

7. **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link (http://zetcode.com/python/prettytable/)

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link. (https://soundcloud.com/applied-ai-course/leakage-bow-and-tfidf)

Applying SVM

[5.2] RBF SVM

In [0]:

```
from sklearn.svm import SVC
from sklearn.model_selection import GridSearchCV

parameter = [10**i for i in range(-5,5)]
#hyperparameter C will be tuned in this range
params = {'C':parameter}
tscv = TimeSeriesSplit(n_splits = 5)
#for time  series cross validation
```

In [0]:

```
#function for findind the optimal hyperparameters

def svm(train_set,train_y):
    model = GridSearchCV(SVC(kernel = 'rbf',gamma = 'auto',probability = True),param_grid = params,cv = tscv
                        scoring = 'roc_auc',verbose = 1,return_train_score = True)
    #we will set gamma to 'auto' to fit the model with less erros,and also returning the probabilites to cal
    #feature importance
    model.fit(train_set,train_y)
    return model
```

In [0]:

```
#plots for tuning
def errors(model):
    best_C = model.best_params_
    #getting the best hyperparameter
    print('best hyperparameter is :',best_C)
    print('best cross validation score is:',model.best_score_)
    t_auc =  model.cv_results_['mean_train_score']
    #adding all train and test score
    cv_auc = model.cv_results_['mean_test_score']


    sns.set_style('darkgrid')
    plt.figure(figsize = (15,6))
    plt.plot(parameter,t_auc,'r',label = 'Training AUC')#plotting the training score
    plt.plot(parameter,cv_auc,'b',label = 'Cross Validation AUC')#plotting the test score
    plt.xscale('log')
    plt.xlabel('Hyperparameters',fontsize  =18)
    plt.ylabel('AUC Scores',fontsize = 18)
    plt.title('AUC vs Hyperparameter',fontsize = 18)
    plt.legend('best')#displaying the best position of the labels
    plt.show()
    return best_C


```

In [0]:

```
#fitting the best classifier

from sklearn.metrics import roc_auc_score

def best_classifier(clf,train_set,train_y,test_set,test_y):

    #clf.fit(train_set,train_y)

    train_pred = clf.predict(train_set)#predicting the values on train data
    test_pred  = clf.predict(test_set)#predicting the values on test data

    p_train = clf.predict_proba(train_set)[:,1]#predicting the probability values on train data
    p_test = clf.predict_proba(test_set)[:,1]#predicting the probability values on test data

    t_auc = roc_auc_score(train_y,p_train)#training auc after fitting best hyperparameter
    cv_auc = roc_auc_score(test_y,p_test)#test score after fitting the best hyperparameter

    print('AUC on Training data is:',t_auc)
    print('AUC on test data is:',cv_auc)
    return t_auc,cv_auc,p_train,p_test,train_pred,test_pred
```

In [0]:

```
#plotting the roc on train and test dat

from sklearn.metrics import roc_curve

def plot_roc(train_y,test_y,train_proba,test_proba,tr_auc,te_auc):
    tr_fpr,tr_tpr,_ = roc_curve(train_y,train_proba)
    te_fpr,te_tpr,_ = roc_curve(test_y,test_proba)
    #calculating the fpr and tpr for each training and test datasets
    sns.set_style('darkgrid')
    plt.figure(figsize=(15,8))
    plt.plot(np.linspace(0,1,100),np.linspace(0,1,100),"g--")#this plots the roc curve for AUC = 0.5
    plt.plot(tr_fpr,tr_tpr,label = 'Training AUC'+str(tr_auc))
    plt.plot(te_fpr,te_tpr,label = 'Test AUC'+str(te_auc))
    plt.xlabel('False Positive Rate(1-specificity)',fontsize=18)
    plt.ylabel('True Positive Rate',fontsize = 18)
    plt.title('ROC CURVE',fontsize=18)
    plt.legend('best')
    plt.show()
```

In [0]:

```
# Calibrated Classifiers to find the probabailities

from sklearn.calibration import CalibratedClassifierCV
from sklearn.calibration import calibration_curve
#computing function for reliability curve
#referred to :https://machinelearningmastery.com/calibrated-classification-model-in-scikit-learn/
def reliability_curve(optimal_clf,trainX, testX, train_y,test_y):
    def uncalibrated(optimal_clf, testX):
     # fit a model)
        #optimal_clf.fit(trainX, train_y)
     # predict probabilities
        return optimal_clf.predict_proba(testX)[:,1]

     #predict calibrated probabilities
    def calibrated(optimal_clf,trainX, testX, train_y):
        # define model
        # define and fit calibration model
        #optimal_clf.fit(trainX,train_y)
        calibrated = CalibratedClassifierCV(optimal_clf, method='sigmoid', cv='prefit')
        calibrated.fit(trainX, train_y)
        # predict probabilities
        return calibrated.predict_proba(testX)[:,1]
    # generate 2 class dataset

    # uncalibrated predictions
    yhat_uncalibrated = uncalibrated(optimal_clf,testX)
    # calibrated predictions
    yhat_calibrated = calibrated(optimal_clf,trainX, testX, train_y)
    # reliability diagrams
    fop_uncalibrated, mpv_uncalibrated = calibration_curve(test_y, yhat_uncalibrated, n_bins=10, normalize=T
    fop_calibrated, mpv_calibrated = calibration_curve(test_y, yhat_calibrated, n_bins=10)
    # plot perfectly calibrated
    plt.figure(figsize = (15,6))
    plt.plot([0, 1], [0, 1], linestyle='--', color='black')
    # plot model reliabilities
    plt.plot(mpv_uncalibrated, fop_uncalibrated, marker='.',label = 'Uncalibrated')
    plt.plot(mpv_calibrated, fop_calibrated, marker='.',label = 'Calibrated')
    plt.xlabel('Expected Probabilities',fontsize  =18)
    plt.ylabel('Predicted Probabilities',fontsize=18)
    plt.legend(loc = 'best')
    plt.title('Calibrated vs Uncalibrated',fontsize  =18)
    plt.show()
```

```

#****************************************************************************************************************

```

In [0]:

```
#function for Confusion Matrices

from sklearn.metrics import confusion_matrix
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score
from sklearn.metrics import precision_score


def plot_cmatrix(test_y,pred_y):
    print('Confusion Matrix')
    C = confusion_matrix(test_y,pred_y)

    A = (((C.T)/(C.sum(axis=1))).T)#for precison matrix
    plt.figure(figsize = (20,4))

    B = (C/C.sum(axis = 0))#for precision matrix
    plt.figure(figsize = (20,4))

    labels = [0,1]
     # representing A in heatmap format
    cmap=sns.light_palette("blue")
    plt.subplot(1, 3, 1)
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Confusion matrix")

    plt.subplot(1, 3, 2)
    sns.heatmap(B, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Precision matrix")

    plt.subplot(1, 3, 3)
    # representing B in heatmap format
    sns.heatmap(A, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Recall matrix")

    plt.show()
```

[5.2.1] Applying RBF SVM on BOW, SET 1

In [0]:

```
svm_bow = svm(train_bow,Y_train)#the model for bag of words
```

```
Fitting 5 folds for each of 10 candidates, totalling 50 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
```

In [0]:

```
import pickle
pickle.dump(svm_bow,open('gdrive/My Drive/svm_bow.p','wb'))#saving the model in drive
```

In [53]:

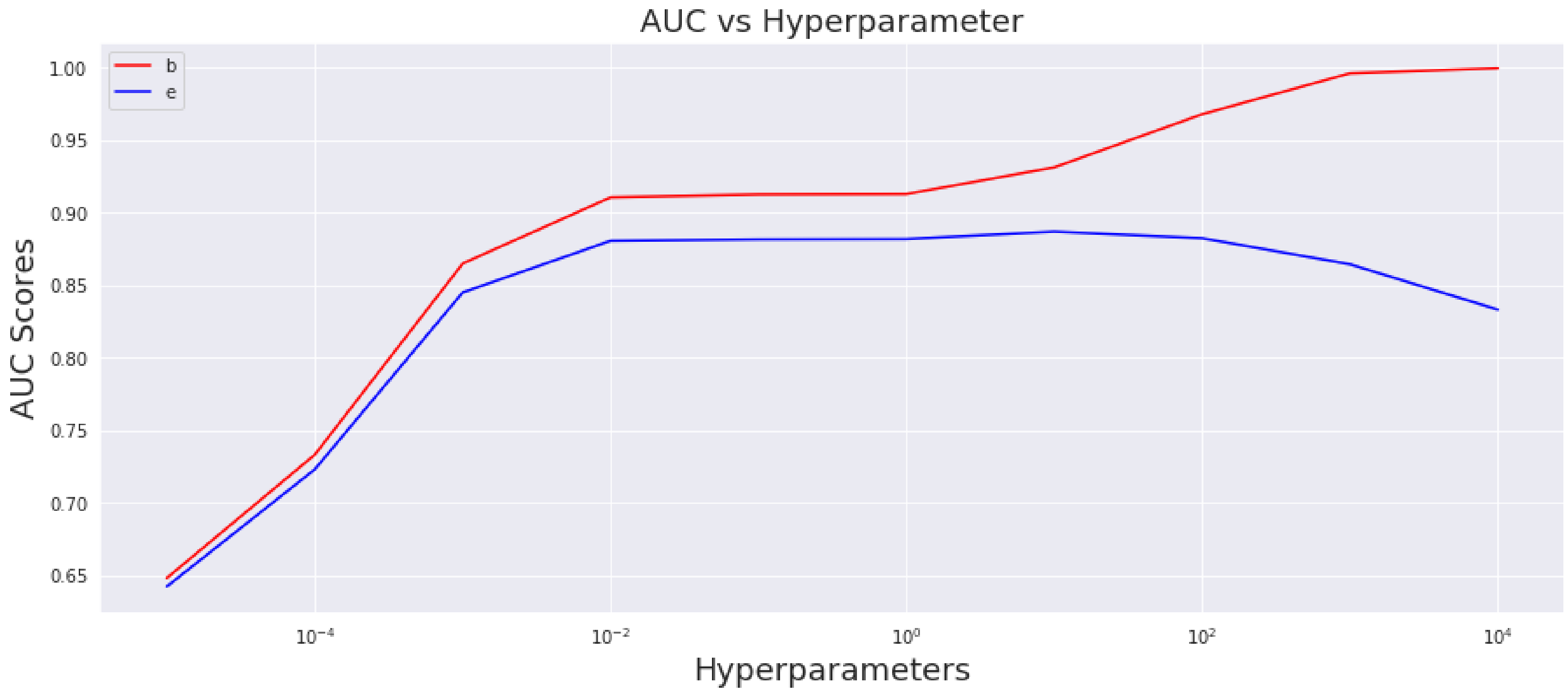
```python
"""loading the model"""
svm_bow = pickle.load(open('gdrive/My Drive/svm_bow.p','rb'))#opening the file
print(svm_bow)
print('******************************************************************')


"""plotting the AUC scores for tuning"""
best_C_bow = errors(svm_bow)['C']#optimal hyperparameter
print("*********************************************************************")

"""Best Classifier"""
#we are initiating the best classifier here to reduce train complexity
svc = SVC(C = best_C_bow,gamma = 'auto',kernel = 'rbf',probability  = True)
svc.fit(train_bow,Y_train)#fitting to the model
train_bow_auc,test_bow_auc,train_proba,test_proba,train_pred,test_pred = best_classifier(svc,train_bow,Y_tra

```

```
GridSearchCV(cv=TimeSeriesSplit(max_train_size=None, n_splits=5),
             error_score='raise-deprecating',
             estimator=SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
                           decision_function_shape='ovr', degree=3,
                           gamma='auto', kernel='rbf', max_iter=-1,
                           probability=True, random_state=None, shrinking=True,
                           tol=0.001, verbose=False),
             iid='warn', n_jobs=None,
             param_grid={'C': [1e-05, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100,
                               1000, 10000]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=1)
******************************************************************
best hyperparameter is : {'C': 10}
best cross validation score is: 0.8868882293781509
```



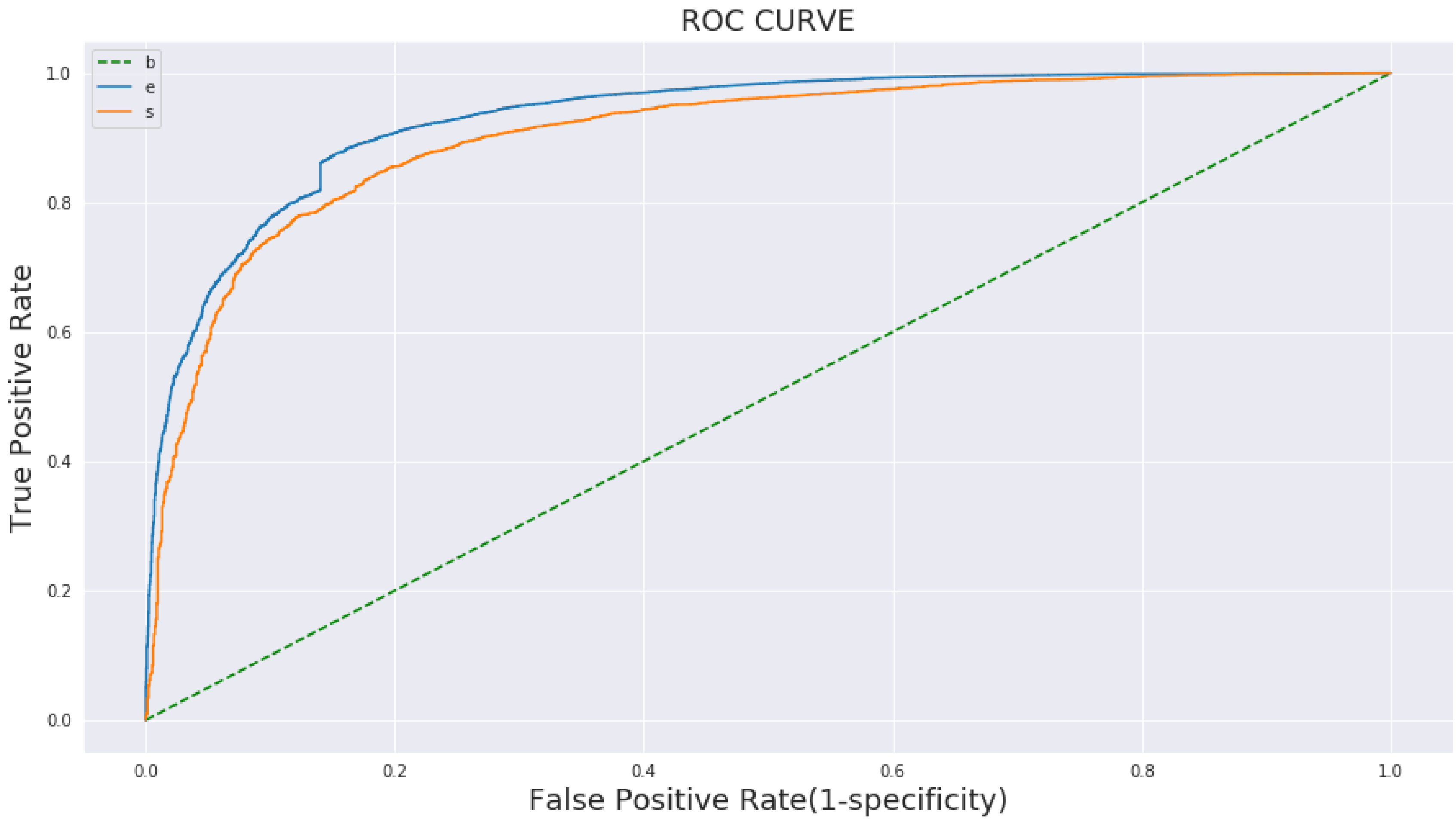
```
********************************************************************
AUC on Training data is: 0.9305006206297534
AUC on test data is: 0.8921253681079008
```

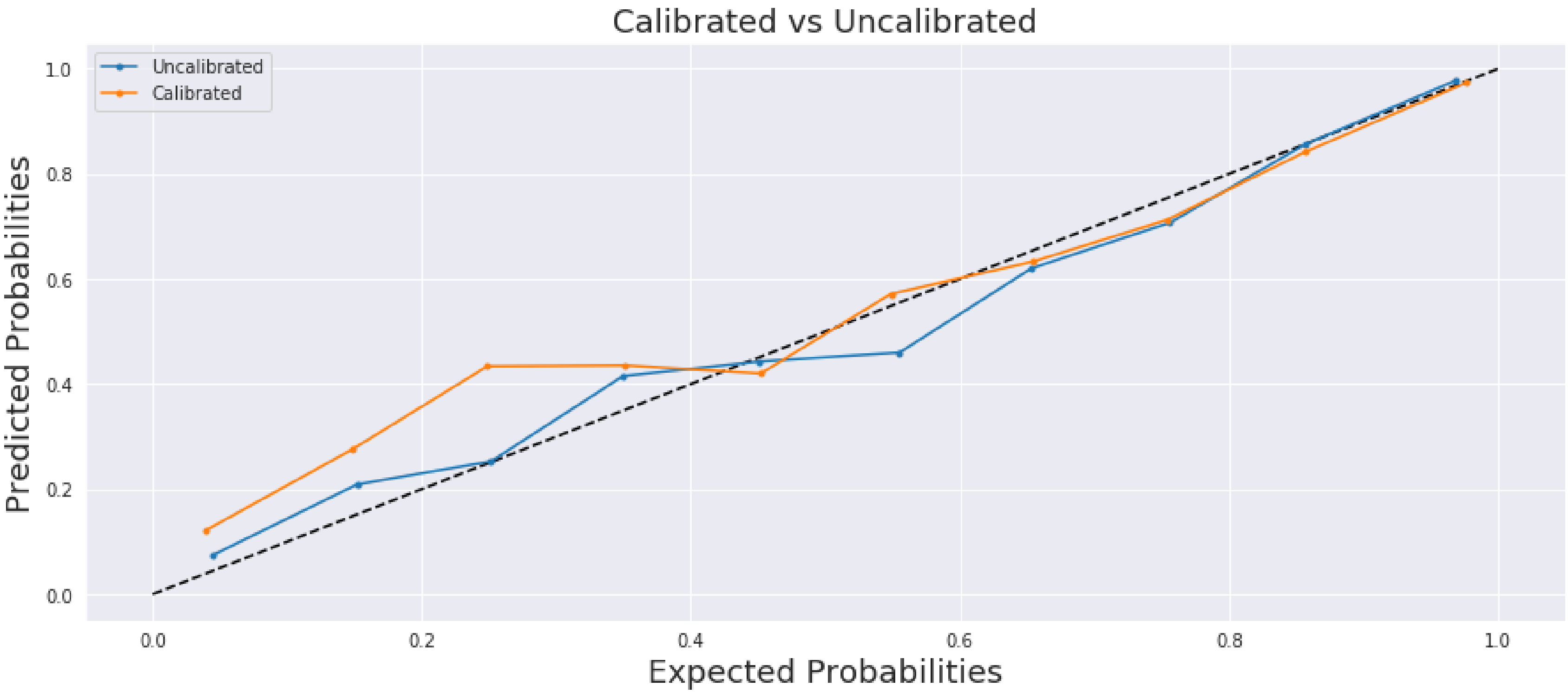
In [0]:

```
"""Plotting the ROC curve"""
plot_roc(Y_train,Y_test,train_proba,test_proba,train_bow_auc,test_bow_auc)


"""Reliability Curve"""
reliability_curve(svc,train_bow,test_bow,Y_train,Y_test)

```




Calibrated vs Uncalibrated
Uncalibrated
Calibrated
Predicted Probabilities
Expected Probabilities
0.0
0.2
0.4
0.6
0.8
1.0

In [0]:

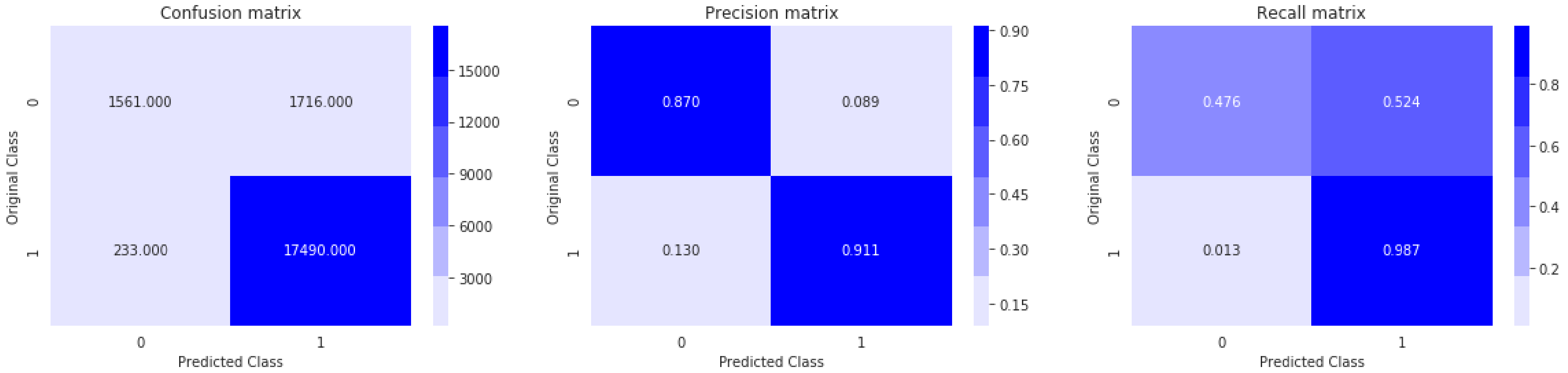
```python
"""Confusion Matrices"""
print('for training data')
plot_cmatrix(Y_train,train_pred)

print('for test data')
plot_cmatrix(Y_test,test_pred)

```

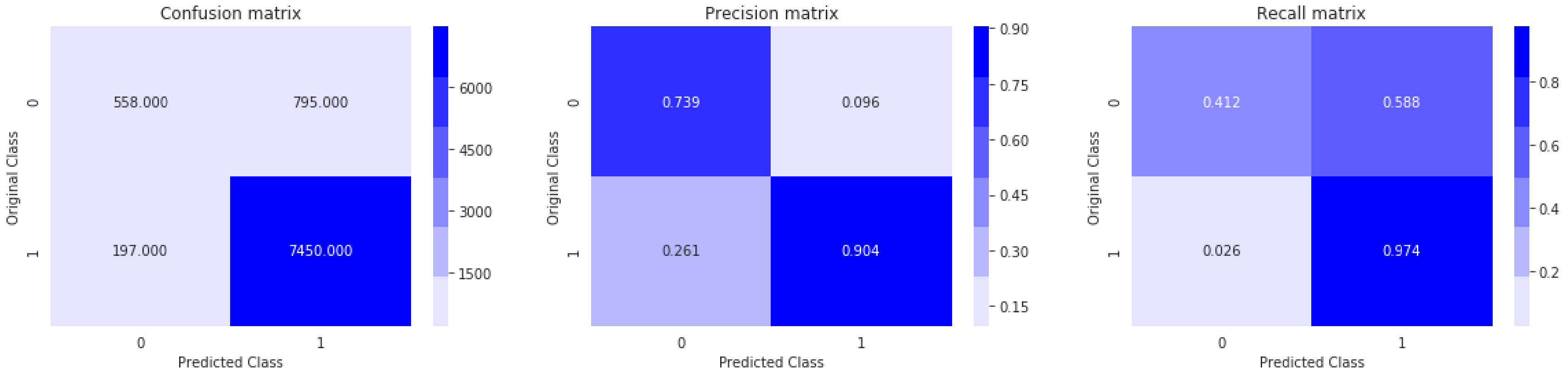
```
for training data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



```
for test data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



[5.2.2] Applying RBF SVM on TFIDF, SET 2

In [0]:

```
# Please write all the code with proper documentation
```

In [55]:

```
svm_tfidf = svm(train_tfidf,Y_train)
```

```
Fitting 5 folds for each of 10 candidates, totalling 50 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done  50 out of  50 | elapsed:  5.2min finished
```

In [0]:

```
pickle.dump(svm_tfidf,open('gdrive/My Drive/svm_tfidf.p','wb'))#saving the model in drive
```

In [57]:

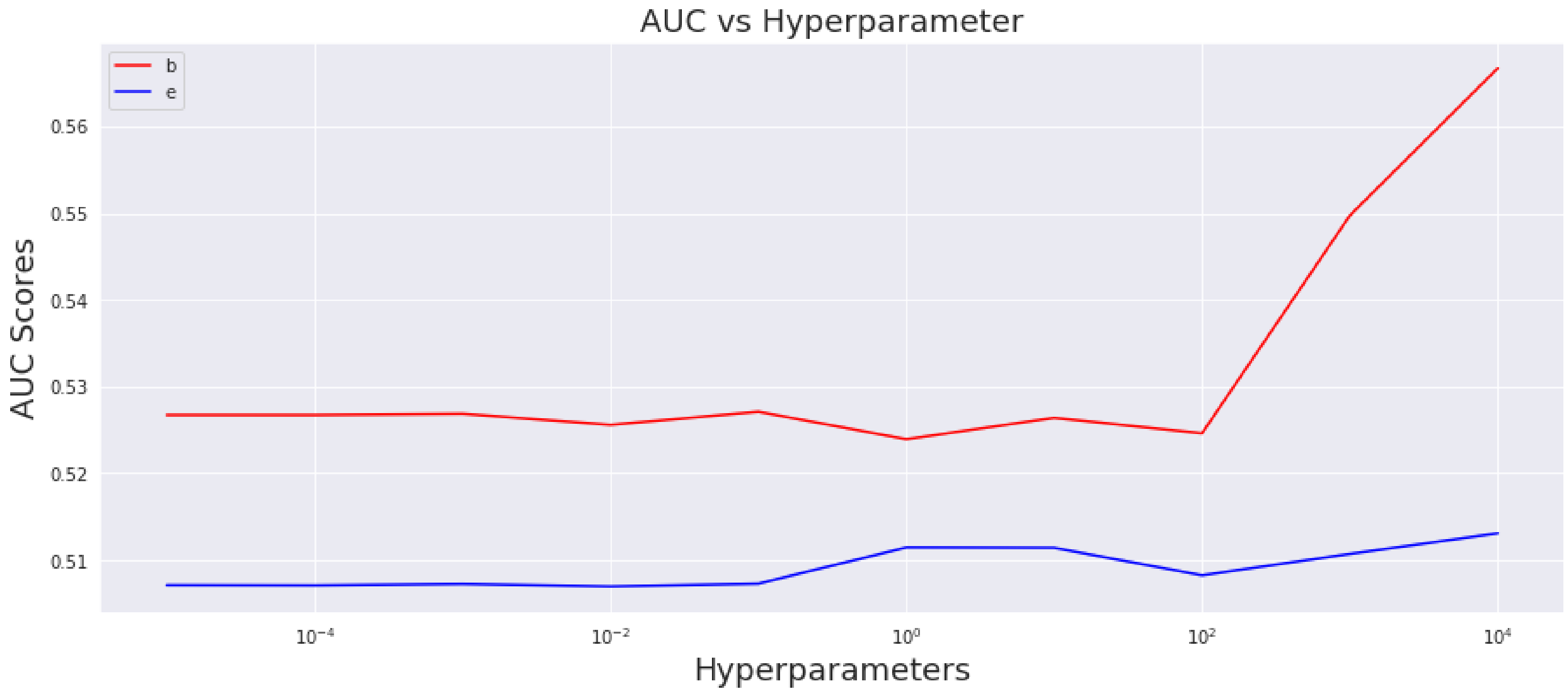
```python
"""loading the model"""
svm_tfidf = pickle.load(open('gdrive/My Drive/svm_tfidf.p','rb'))#opening the file
print(svm_tfidf)
print('*****************************************************************')


"""plotting the AUC scores for tuning"""
best_C_tfidf = errors(svm_tfidf)['C']#optimal hyperparameter
print("********************************************************************")

"""Best Classifier"""
#we are initiating the best classifier here to reduce train complexity
svc = SVC(C = best_C_tfidf,gamma = 'auto',kernel = 'rbf',probability  = True)
svc.fit(train_tfidf,Y_train)#fitting to the model
train_tfidf_auc,test_tfidf_auc,train_proba,test_proba,train_pred,test_pred = best_classifier(svc,train_tfidf

```

```
GridSearchCV(cv=TimeSeriesSplit(max_train_size=None, n_splits=5),
             error_score='raise-deprecating',
             estimator=SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
                           decision_function_shape='ovr', degree=3,
                           gamma='auto', kernel='rbf', max_iter=-1,
                           probability=True, random_state=None, shrinking=True,
                           tol=0.001, verbose=False),
             iid='warn', n_jobs=None,
             param_grid={'C': [1e-05, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100,
                               1000, 10000]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=1)
*****************************************************************
best hyperparameter is : {'C': 10000}
best cross validation score is: 0.5130975592237403
```



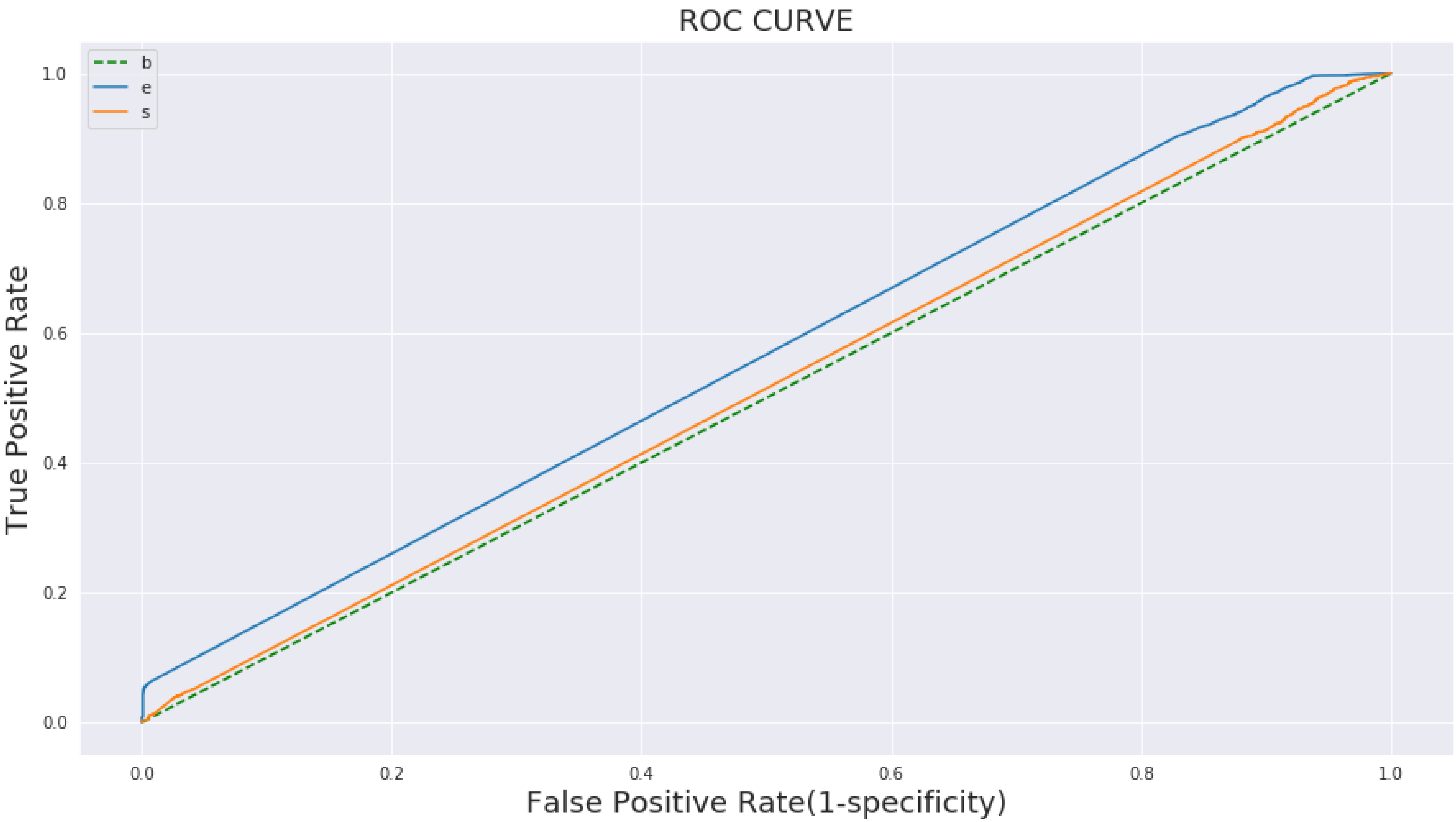
```
*********************************************************************
AUC on Training data is: 0.5544149989982038
AUC on test data is: 0.5034864161501715
```

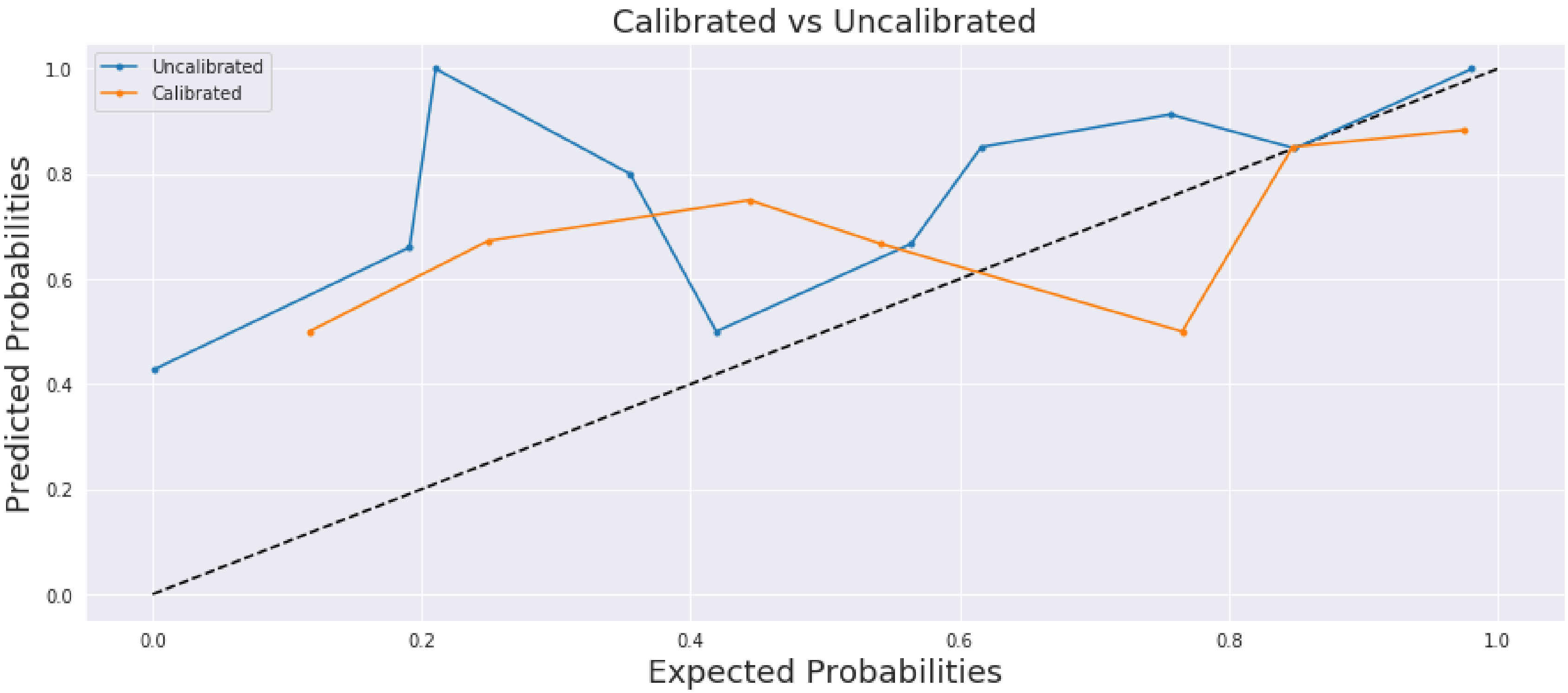
In [0]:

```python
"""Plotting the ROC curve"""
plot_roc(Y_train,Y_test,train_proba,test_proba,train_tfidf_auc,test_tfidf_auc)


"""Reliability Curve"""
reliability_curve(svc,train_tfidf,test_tfidf,Y_train,Y_test)

```




Calibrated vs Uncalibrated
Uncalibrated
Calibrated
Predicted Probabilities
Expected Probabilities
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0

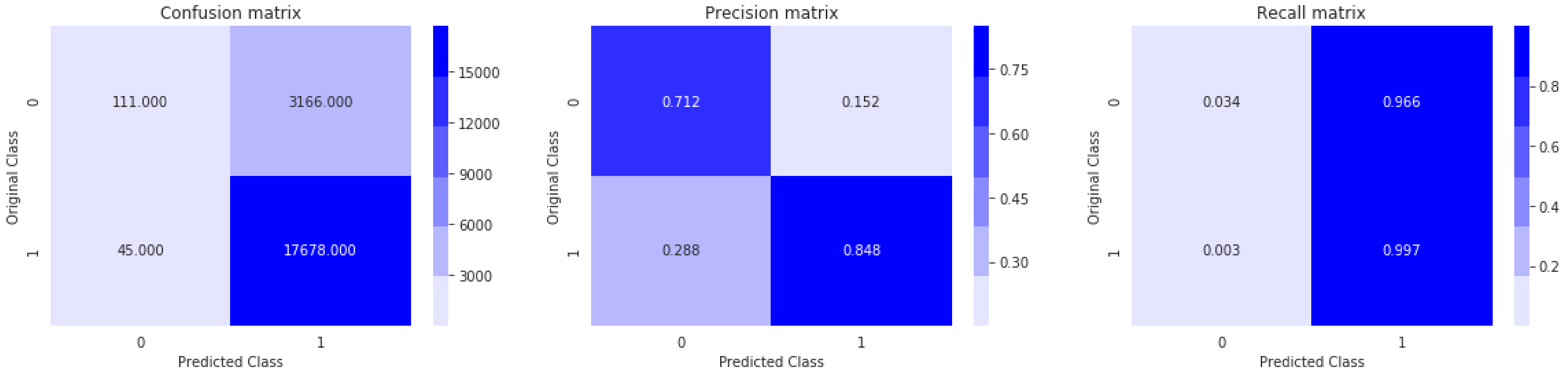
In [0]:

```
""Confusion Matrices"""
print('for training data')
plot_cmatrix(Y_train,train_pred)

print('for test data')
plot_cmatrix(Y_test,test_pred)
```

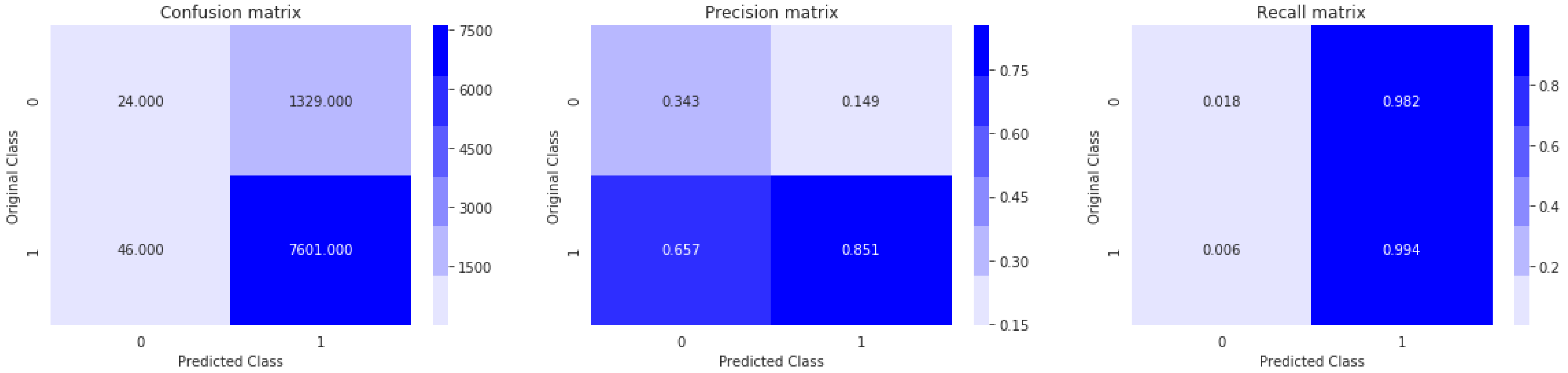
```
for training data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



```
for test data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



[5.2.3] Applying RBF SVM on AVG W2V, SET 3

In [0]:

```
# Please write all the code with proper documentation
svm_avgw2v = svm(train_avgw2v,Y_train)
```

```
Fitting 5 folds for each of 10 candidates, totalling 50 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done  50 out of  50 | elapsed: 73.2min finished
```

In [0]:

```
pickle.dump(svm_avgw2v,open('gdrive/My Drive/svm_avgw2v.p','wb'))#saving the model in drive
```

In [61]:

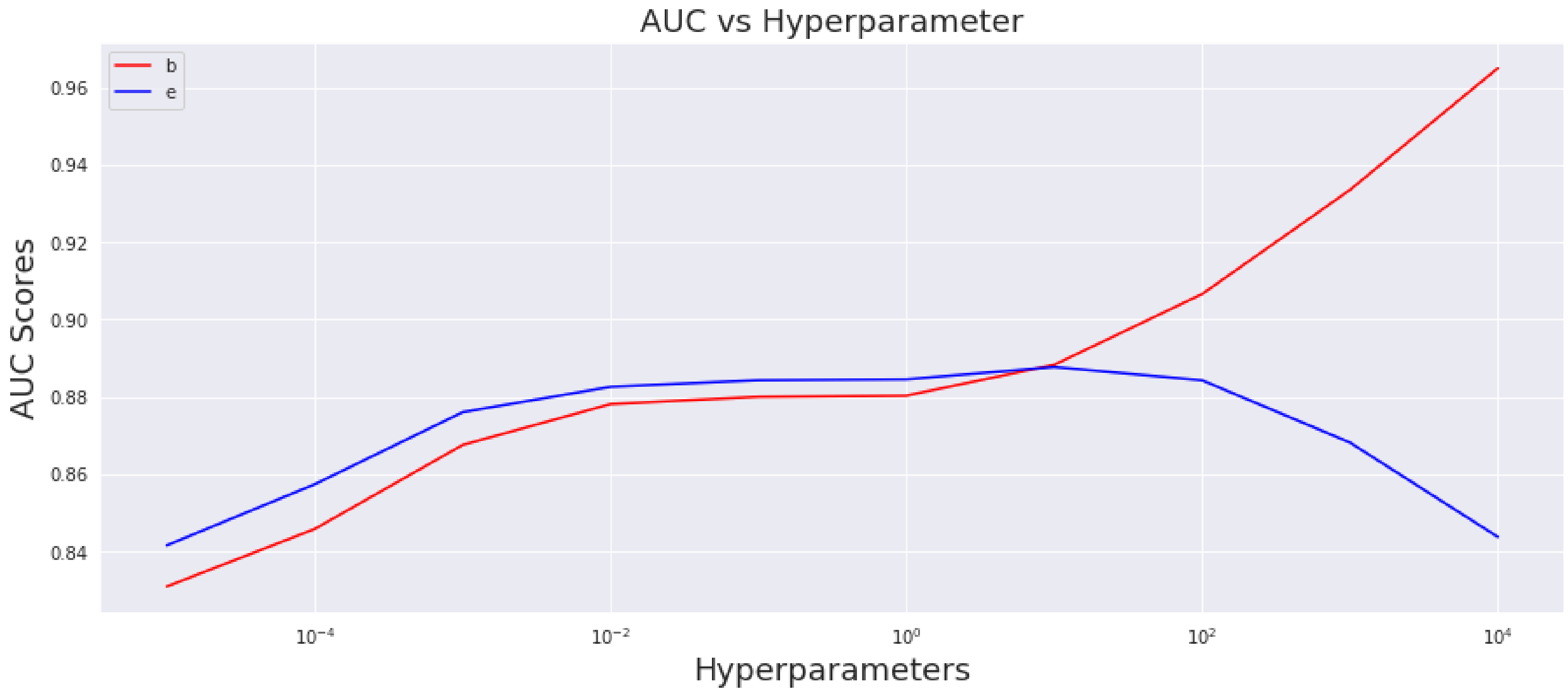
```python
"""loading the model"""
svm_avgw2v = pickle.load(open('gdrive/My Drive/svm_avgw2v.p','rb'))#opening the file
print(svm_avgw2v)
print('******************************************************************')


"""plotting the AUC scores for tuning"""
best_C_avgw2v = errors(svm_avgw2v)['C']#optimal hyperparameter
print("**********************************************************************")

"""Best Classifier"""
#we are initiating the best classifier here to reduce train complexity
svc = SVC(C = best_C_avgw2v,gamma = 'auto',kernel = 'rbf',probability  = True)
svc.fit(train_avgw2v,Y_train)#fitting to the model
train_avgw2v_auc,test_avgw2v_auc,train_proba,test_proba,train_pred,test_pred = best_classifier(svc,train_avg

```

```
GridSearchCV(cv=TimeSeriesSplit(max_train_size=None, n_splits=5),
             error_score='raise-deprecating',
             estimator=SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
                           decision_function_shape='ovr', degree=3,
                           gamma='auto', kernel='rbf', max_iter=-1,
                           probability=True, random_state=None, shrinking=True,
                           tol=0.001, verbose=False),
             iid='warn', n_jobs=None,
             param_grid={'C': [1e-05, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100,
                               1000, 10000]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=1)
******************************************************************
best hyperparameter is : {'C': 10}
best cross validation score is: 0.8877387558774296
```



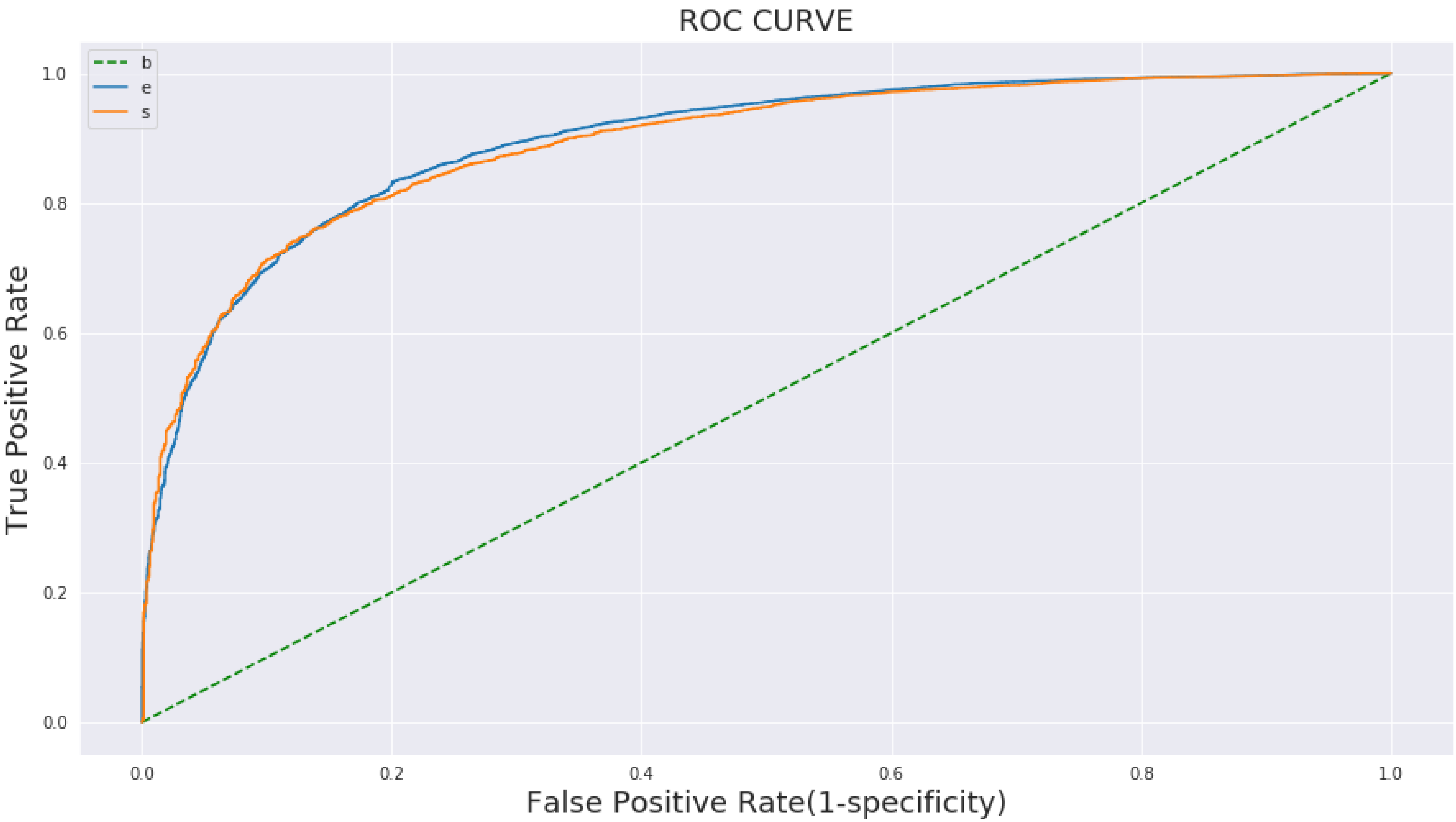
```
*********************************************************************
AUC on Training data is: 0.8958923852149814
AUC on test data is: 0.8851873371524027
```

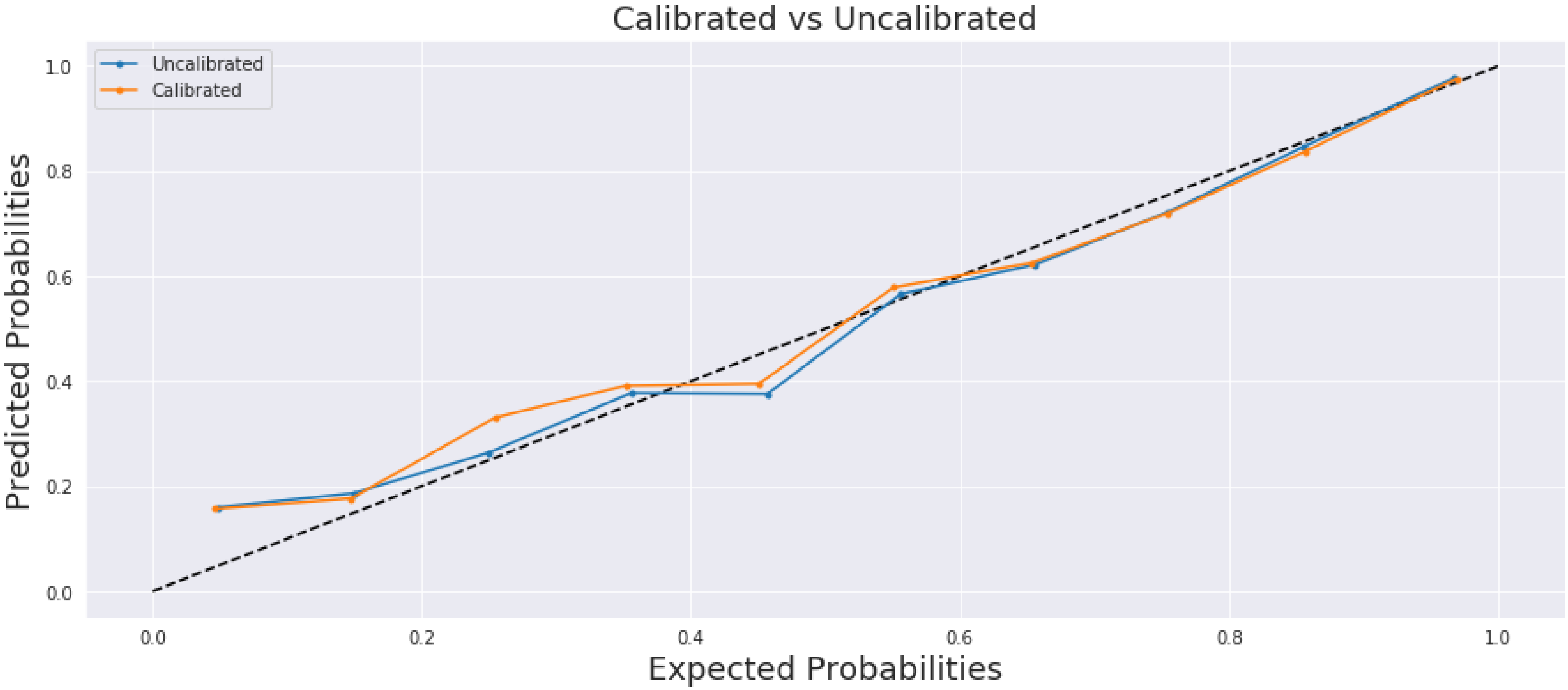
In [0]:

```
"""Plotting the ROC curve"""
plot_roc(Y_train,Y_test,train_proba,test_proba,train_avgw2v_auc,test_avgw2v_auc)


"""Reliability Curve"""
reliability_curve(svc,train_avgw2v,test_avgw2v,Y_train,Y_test)

```




Calibrated vs Uncalibrated
Uncalibrated
Calibrated
Predicted Probabilities
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Expected Probabilities

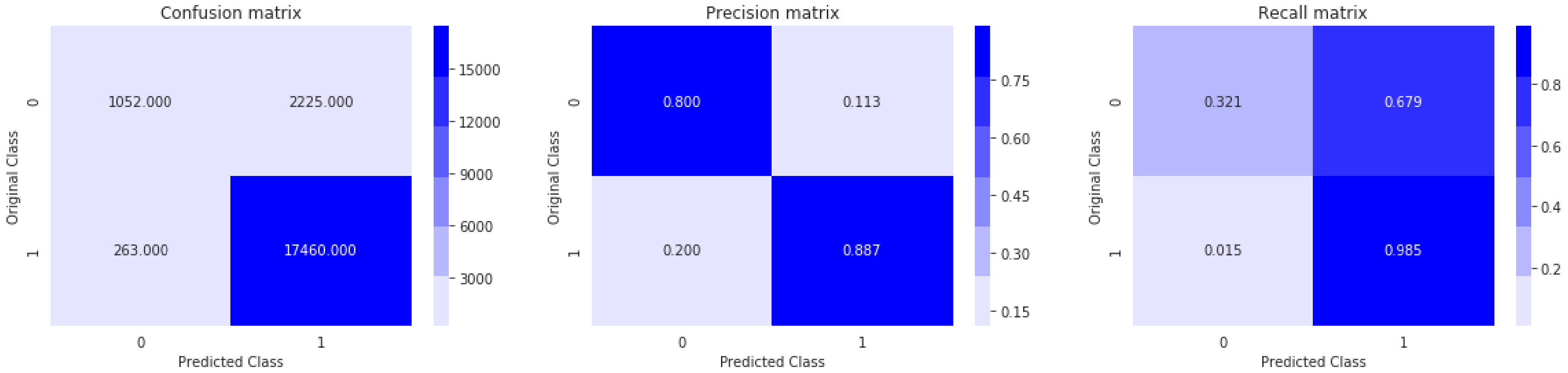
In [0]:

```python
"""Confusion Matrices"""
print('for training data')
plot_cmatrix(Y_train,train_pred)

print('for test data')
plot_cmatrix(Y_test,test_pred)
```

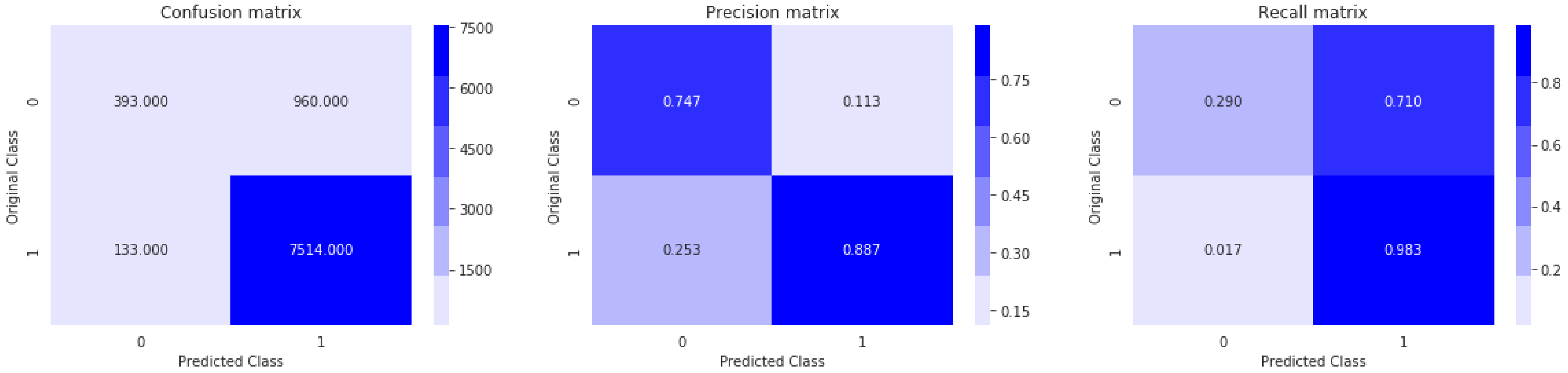
```
for training data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



```
for test data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



[5.2.4] Applying RBF SVM on TFIDF W2V, SET 4

In [0]:

```
# Please write all the code with proper documentation
```

In [47]:

```
svm_tfidfw2v = svm(train_tfidfw2v,Y_train)
```

```
Fitting 5 folds for each of 10 candidates, totalling 50 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done  50 out of  50 | elapsed: 102.1min finished
```

In [0]:

```
pickle.dump(svm_tfidfw2v,open('gdrive/My Drive/svm_tfidfw2v.p','wb'))#saving the model in drive
```

In [49]:

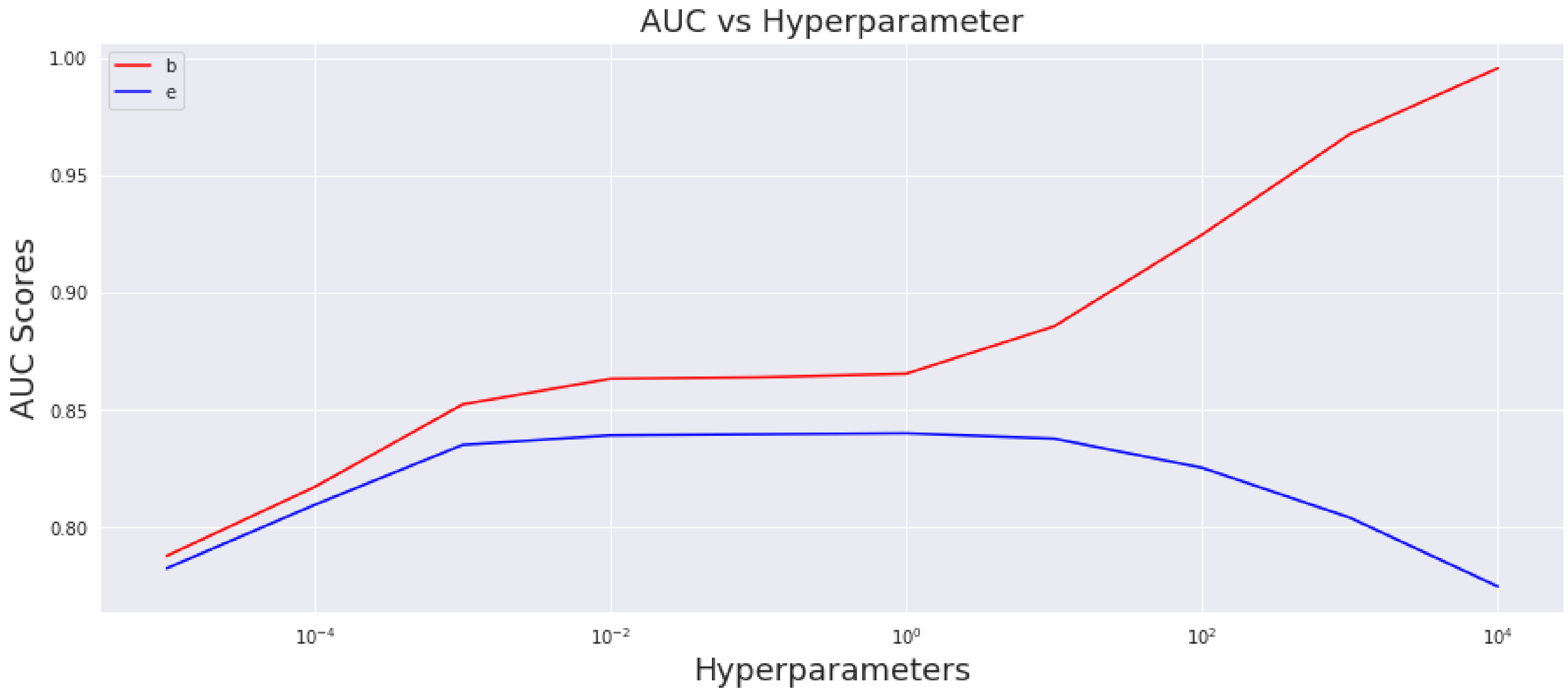
```
"""loading the model"""
svm_tfidfw2v = pickle.load(open('gdrive/My Drive/svm_tfidfw2v.p','rb'))#opening the file
print(svm_tfidfw2v)
print('******************************************************************')


"""plotting the AUC scores for tuning"""
best_C_tfidfw2v = errors(svm_tfidfw2v)['C']#optimal hyperparameter
print("*********************************************************************")

"""Best Classifier"""
#we are initiating the best classifier here to reduce train complexity
svc = SVC(C = best_C_tfidfw2v,gamma = 'auto',kernel = 'rbf',probability  = True)
svc.fit(train_tfidfw2v,Y_train)#fitting to the model
train_tfidfw2v_auc,test_tfidfw2v_auc,train_proba,test_proba,train_pred,test_pred = best_classifier(svc,train

```

```
GridSearchCV(cv=TimeSeriesSplit(max_train_size=None, n_splits=5),
             error_score='raise-deprecating',
             estimator=SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
                           decision_function_shape='ovr', degree=3,
                           gamma='auto', kernel='rbf', max_iter=-1,
                           probability=True, random_state=None, shrinking=True,
                           tol=0.001, verbose=False),
             iid='warn', n_jobs=None,
             param_grid={'C': [1e-05, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100,
                               1000, 10000]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='roc_auc', verbose=1)
******************************************************************
best hyperparameter is : {'C': 1}
best cross validation score is: 0.8401767620966667
```



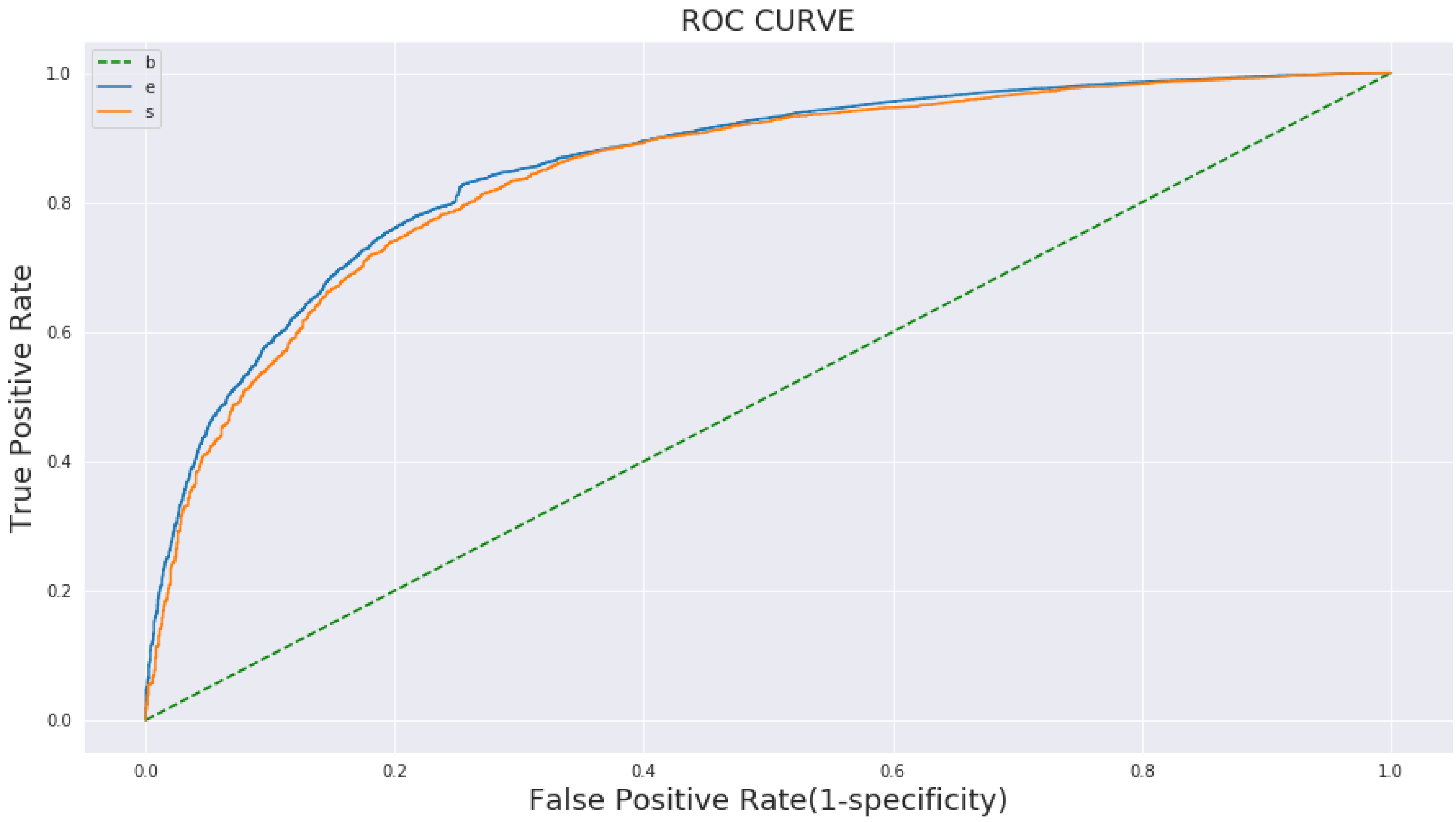
```
*********************************************************************
AUC on Training data is: 0.8561757958119618
AUC on test data is: 0.8449966441232817
```

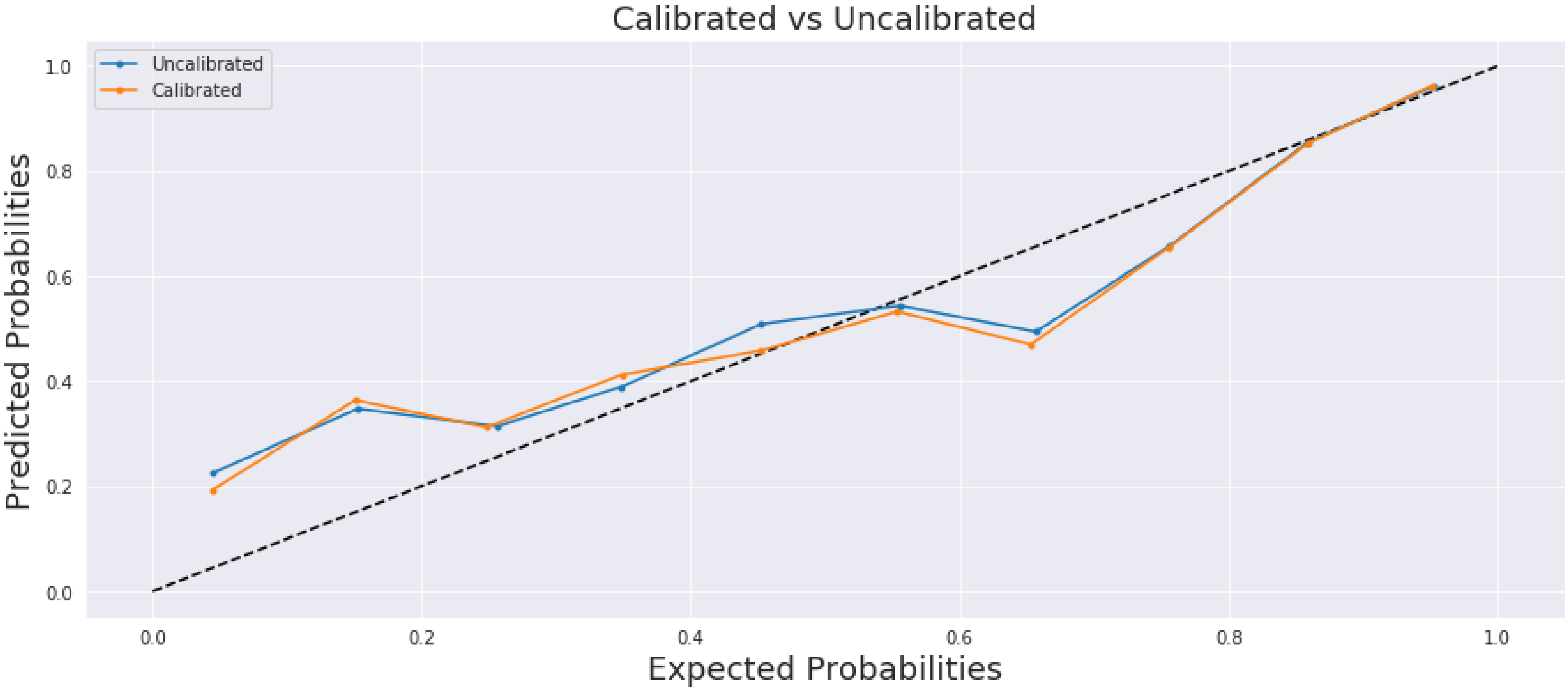
In [50]:

```
"""Plotting the ROC curve"""
plot_roc(Y_train,Y_test,train_proba,test_proba,train_tfidfw2v_auc,test_tfidfw2v_auc)


"""Reliability Curve"""
reliability_curve(svc,train_tfidfw2v,test_tfidfw2v,Y_train,Y_test)

```




Calibrated vs Uncalibrated
Uncalibrated
Calibrated
Predicted Probabilities
Expected Probabilities
0.0
0.2
0.4
0.6
0.8
1.0

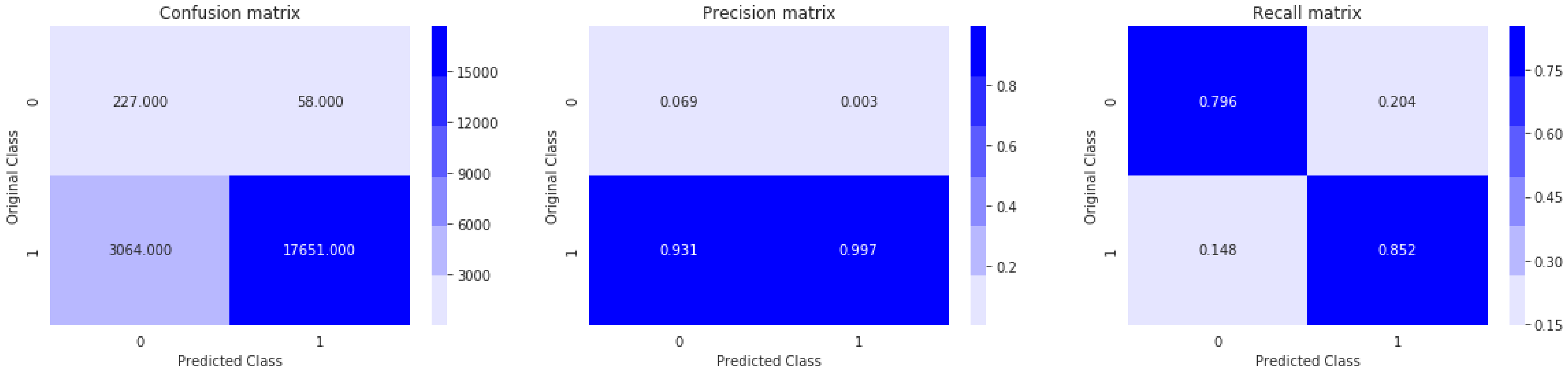
In [52]:

```python
"""Confusion matrices"""
print('for training data')
plot_cmatrix(train_pred,Y_train)

print('for test data')
plot_cmatrix(test_pred,Y_test)
```

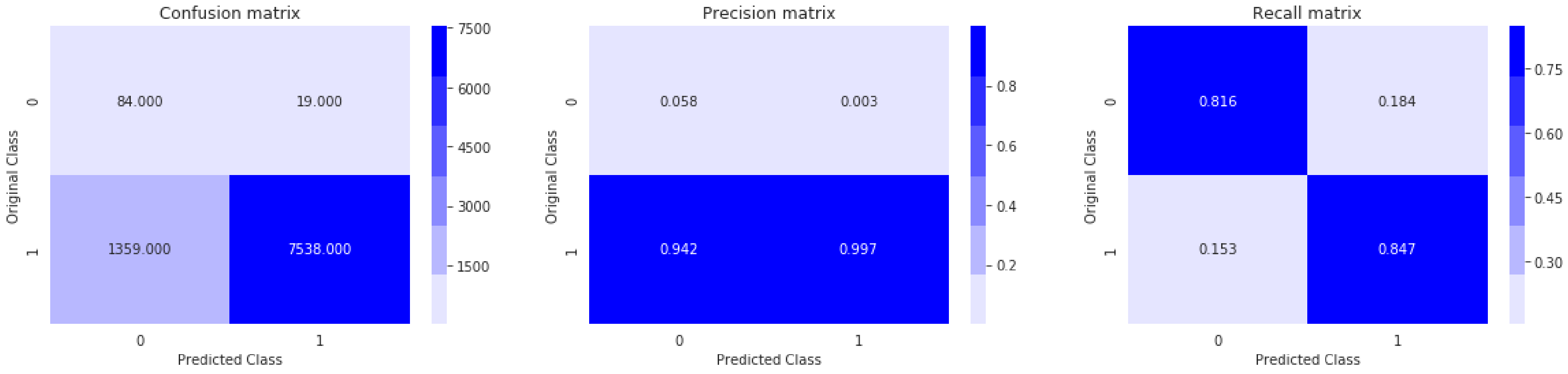
```
for training data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



```
for test data
Confusion Matrix

<Figure size 1440x288 with 0 Axes>
```



[6] Conclusions

In [63]:

```
from prettytable import PrettyTable

table = PrettyTable()
no = [1,2,3,4,]
vectorizers = ['Bag of vectors','TFIDF','Average Word 2 vector','TFIDF Word 2 Vector']#all vectorizers
#regularization = ['l2','l1','l2','l1','l2','l1','l2','l1']
C = [best_C_bow,best_C_tfidf,best_C_avgw2v,best_C_tfidfw2v]
AUC = [test_bow_auc,test_tfidf_auc,test_avgw2v_auc,test_tfidfw2v_auc]#their respective auc scores

table.add_column("SNo",no)
table.add_column('Vectorizers',vectorizers)
#table.add_column('Regularization',regularization)
table.add_column('Hyperparameter(1/lambda)',C)
table.add_column('AUC on test',AUC)
print('\t\t\t Table for Support Vector Classifier')
print(table)
```

```
                          Table for Support Vector Classifier
+-----+-----------------------+--------------------------+--------------------+
| SNo |      Vectorizers      | Hyperparameter(1/lambda) |    AUC on test     |
+-----+-----------------------+--------------------------+--------------------+
|  1  |     Bag of vectors    |            10            | 0.8921253681079008 |
|  2  |         TFIDF         |          10000           | 0.5034864161501715 |
|  3  | Average Word 2 vector |            10            | 0.8851873371524027 |
|  4  |  TFIDF Word 2 Vector  |            1             | 0.8449966441232817 |
+-----+-----------------------+--------------------------+--------------------+
```

- In Support Vector Classifier BAG of Words stood out as the best featurizer with highest auc on test data.
- as C increase,i.e Lambda decreases the model tends to overfit .

In [ ]: