PD2

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Project PD2

import packages

```
In [106]: import datascience as ds
          from datascience import *
          import numpy as np
          from collections import Counter
          from graphviz import Source
          import pandas as pd
          import seaborn as sns
          from sklearn.pipeline import Pipeline
          from sklearn.feature_extraction.text import CountVectorizer, TfidfTransformer
          from sklearn.tree import DecisionTreeClassifier
          from sklearn.ensemble import RandomForestClassifier
          from sklearn import tree
          from sklearn.metrics import confusion_matrix, precision_score, recall_score, f1_score, accu
          import matplotlib.pyplot as plt
          from sklearn.model_selection import train_test_split, cross_val_score, StratifiedKFold
          from sklearn.externals import joblib
          %matplotlib inline
```

tweets data loaded into Jupyter Notebook as Table object

```
In [107]: df1 = ds.Table.read_table('Climate1SupportiveLevel.csv', sep=',')
          df2 = ds.Table.read_table('ClimateBalancedDS2.csv', sep=',')
          df = df1.append(df2)
          test_index = np.random.choice(df.num_rows, 100, replace=False)
          train_val_index = [i for i in np.arange(df.num_rows) if i not in test_index]
          test_data = df.take[test_index]
          df = df.take[train_val_index]
          X = list(df['Text'])
          y = list(df['Support'])
```

A description of all model enhancements incorporated into the construction of PD2.

used parameters

- CountVector

  - analyzer = 'word'
  - stop_words = the top 30 most common words in DS1+DS2 tweets
  - min_df = 3
  - ngram_range=(1,2)

- DecisionTree

  - criterion='entropy'
  - max_depth =
  - min_samples_leaf = 2

A description of all model parameters you tried and the associated Stratified k-fold cross validation results for each model parameter choice based on the combined data set (DS1 + DS2)

- max_depth=range(1, 15)
- stop_words:

  - default in CountVectorizer: 'english'
  - user_defined: ['a', 'an', 'the', 'it', 'is', 'are', 'be', 'of', 'this', 'that', 'RT', 'rt','https']
  - the top 30 most common words in DS1+DS2 tweets (chosen)

code and test results as follows:

Check whether the data distribution is balanced

```
In [108]: def check(sentiment, index, note='training'):
              if sentiment==0:
                  label = 'not supportive'
              else:
                  label = 'supportive'
              print('There are {} '.format(df.take(index).where('Support',
                    are.equal_to(sentiment)).size[0][0])+label+' tweets in the '+note+' set.')
```

Model Building

```
In [109]: def custom_split(train_index, test_index):
              trainingset = df.take(train_index)
              testingset = df.take(test_index)

              X_train= list(trainingset['Text'])
              y_train= list(trainingset['Support'])
              X_test= list(testingset['Text'])
              y_test= list(testingset['Support'])

              return X_train, X_test, y_train, y_test
```

classifier

```
In [110]: def classifier(X_train, y_train, X_test, fold, max_depth, min_samples_leaf, stop_words, ove
              # token_pattern='(([#@]|[0-9]|[a-z]|[A-Z])+)'
              clf = Pipeline(
                  [
                      ('vect', CountVectorizer(token_pattern="(?!RT|rt|\d+)[@#]*[\w\'_-]{2,100}",
                                               analyzer = 'word',
                                               stop_words = stop_words,
                                               min_df = 3,
                                               ngram_range=(1,2))),
                      ('clf', DecisionTreeClassifier(criterion='entropy',
                                                     random_state = 100,
                                                     max_depth = max_depth,
                                                     min_samples_leaf = min_samples_leaf))
                  ])
              clf.fit(X_train, y_train)
              feature_names = clf.named_steps['vect'].get_feature_names()
              try:
                  dot_data = tree.export_graphviz(clf.named_steps['clf'], out_file=None,
                                                  feature_names=feature_names)
                  graph = Source(dot_data)
                  graph.render('ClimateClassifier-Fold_{}'.format(fold))
              except Exception as e:
                  print(e)
              predicted_y_train = clf.predict(X_train)
              predicted_y_test = clf.predict(X_test)
              # save as pickle
              if overfit_risk:
                  joblib.dump(clf, 'ClimateTeam7PD2_maxdepth{}.pkl'.format(max_depth))
              else:
                  joblib.dump(clf, 'ClimateTeam7PD2.pkl')
              return predicted_y_train, predicted_y_test
```

evaluation

```
In [111]: def eval_results(predicted_y_train, y_train, predicted_y_test, y_test):
              accuracy_s = accuracy_score(y_test, predicted_y_test)
              precision_s = precision_score(y_test, predicted_y_test)
              recall_s = recall_score(y_test, predicted_y_test)
              f1_s = f1_score(y_test, predicted_y_test)
              cm_train = confusion_matrix(y_train, predicted_y_train)
              cm_test = confusion_matrix(y_test, predicted_y_test)

              print('Accuracy Score:', accuracy_s)
              print("Precision Score:", precision_s)
              print("Recall Score:", recall_s)
              print("f1 Score:", f1_s)
```

```
        print('confusion_matrix of training set is: \n', cm_train, '\n')
        print('confusion_matrix of testing set is: \n', cm_test, '\n')
        print(classification_report(y_test, predicted_y_test))

        classes = ['not supportive', 'supportive']
        sns.heatmap(cm_train, annot=True, cmap='Blues', yticklabels=classes,
         xticklabels=classes)
        plt.title('confusion matrix of training set')
        plt.show()
        sns.heatmap(cm_test, annot=True, cmap='Blues', yticklabels=classes,
         xticklabels=classes)
        plt.title('confusion matrix of testing set')
        plt.show()
        return accuracy_s, precision_s, recall_s, f1_s
```

k-fold

```
In [112]: def k_fold_evaluate(X, y, max_depth, min_samples_leaf, stop_words, print_eval=True,
                               overfit_risk=False):
        # initialization
        accuracy = []
        precision = []
        recall=[]
        f1 = []
        fold = 1
        skf = StratifiedKFold(n_splits=5, random_state=1, shuffle= True)

        # build model and collect results
        for val_index, test_index in skf.split(X, y):
            X_train, X_val, y_train, y_val = custom_split(val_index, test_index)

            predicted_y_train, predicted_y_val = classifier(X_train=X_train, y_train=y_train,
                                                            X_test=X_val, fold=fold,
                                                            max_depth = max_depth,
                                                            min_samples_leaf = min_samples_le
                                                            stop_words = stop_words,
                                                            overfit_risk=overfit_risk)
            metrics_df={}
            if print_eval:
                print('\nFold: {}'.format(fold))
                accuracy_s, precision_s, recall_s, f1_s = eval_results(predicted_y_train,
                                                        y_train, predicted_y_val, y_val)
                accuracy.append(accuracy_s)
                precision.append(precision_s)
                recall.append(recall_s)
                f1.append(f1_s)

                metrics_df = pd.DataFrame(
```

```
                                {
                                    'accuracy': accuracy,
                                    'precision': precision,
                                    'recall':recall,
                                    'f1':f1
                                }
                            )
                    fold += 1
            return metrics_df
```

Tests:

test1: stop-words: default

```
In [113]: test_X = list(test_data['Text'])
          test_y = list(test_data['Support'])
```

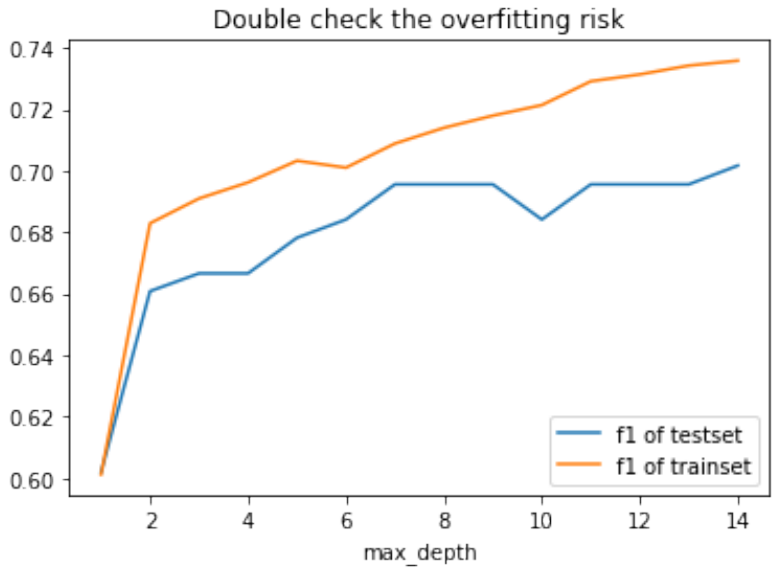
```
In [117]: f1_lst_test1 = []
          f1_lst_train1 = []
          for d in range(1, 15):
              k_fold_evaluate(X, y, max_depth=d, min_samples_leaf=2, stop_words='english', print_eval
              clf_tmp = joblib.load('ClimateTeam7PD2_maxdepth{}.pkl'.format(d))
              print('maxdepth=', d)
              # test
              y_pred = clf_tmp.predict(test_X)
              print('test f1')
              print(f1_score(y_pred=y_pred, y_true=test_y))
              f1_lst_test1.append(f1_score(y_pred=y_pred, y_true=test_y))
              # train_val
              y_pred = clf_tmp.predict(X)
              print('train f1')
              print(f1_score(y_pred=y_pred, y_true=y))
              f1_lst_train1.append(f1_score(y_pred=y_pred, y_true=y))
```

```
maxdepth= 1
test f1
0.6019417475728155
train f1
0.6012009890498058
maxdepth= 2
test f1
0.6608695652173913
train f1
0.6829733163913596
maxdepth= 3
test f1
0.6666666666666666
train f1
0.6910466582597731
```

```
maxdepth= 4
test f1
0.6666666666666666
train f1
0.6962822936357909
maxdepth= 5
test f1
0.6782608695652174
train f1
0.7033312382149591
maxdepth= 6
test f1
0.6842105263157895
train f1
0.7010834926704909
maxdepth= 7
test f1
0.6956521739130435
train f1
0.7089410272669627
maxdepth= 8
test f1
0.6956521739130435
train f1
0.7140600315955766
maxdepth= 9
test f1
0.6956521739130435
train f1
0.7180296810862015
maxdepth= 10
test f1
0.6842105263157895
train f1
0.7214669617451785
maxdepth= 11
test f1
0.6956521739130435
train f1
0.7292057535959976
maxdepth= 12
test f1
0.6956521739130435
train f1
0.7314465408805032
maxdepth= 13
test f1
0.6956521739130435
```

```
train f1
0.7343208320201702
maxdepth= 14
test f1
0.7017543859649122
train f1
0.7359143846395971
```

```
In [119]: plt.plot(np.arange(1,15), f1_lst_test1, label='f1 of testset')
          plt.plot(np.arange(1,15), f1_lst_train1, label='f1 of trainset')
          plt.xlabel('max_depth')
          plt.title('Double check the overfitting risk')
          plt.legend(loc='lower right')
          plt.show()
```



test2: stop_words: ['a', 'an', 'the', 'it', 'is', 'are', 'be', 'of', 'this', 'that', 'RT', 'rt','https']

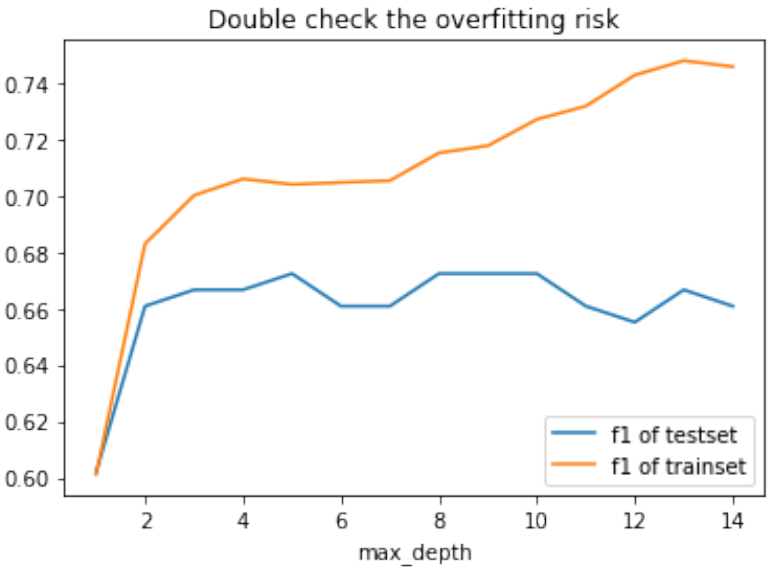
```
In [121]: f1_lst_test2 = []
          f1_lst_train2 = []
          for d in range(1, 15):
              k_fold_evaluate(X, y, max_depth=d, min_samples_leaf=2,
                              stop_words=['a', 'an', 'the', 'it', 'is', 'are', 'be', 'of', 'this', 't
                              print_eval=False, overfit_risk=True)
              clf_tmp = joblib.load('ClimateTeam7PD2_maxdepth{}.pkl'.format(d))
              print('maxdepth=', d)
              # test
              y_pred = clf_tmp.predict(test_X)
```

```
            print('test f1')
            print(f1_score(y_pred=y_pred, y_true=test_y))
            f1_lst_test2.append(f1_score(y_pred=y_pred, y_true=test_y))
            # train_val
            y_pred = clf_tmp.predict(X)
            print('train f1')
            print(f1_score(y_pred=y_pred, y_true=y))
            f1_lst_train2.append(f1_score(y_pred=y_pred, y_true=y))
```

```
maxdepth= 1
test f1
0.6019417475728155
train f1
0.6012009890498058
maxdepth= 2
test f1
0.6608695652173913
train f1
0.6829733163913596
maxdepth= 3
test f1
0.6666666666666665
train f1
0.7001540832049308
maxdepth= 4
test f1
0.6666666666666665
train f1
0.7059902200488998
maxdepth= 5
test f1
0.6724137931034483
train f1
0.704040087691826
maxdepth= 6
test f1
0.6608695652173913
train f1
0.704713049054184
maxdepth= 7
test f1
0.6608695652173913
train f1
0.7053915275994865
maxdepth= 8
test f1
0.6724137931034483
train f1
```

```
0.7151819322459222
maxdepth= 9
test f1
0.6724137931034483
train f1
0.7177522349936144
maxdepth= 10
test f1
0.6724137931034483
train f1
0.727102219443576
maxdepth= 11
test f1
0.6608695652173913
train f1
0.7317839195979898
maxdepth= 12
test f1
0.6551724137931034
train f1
0.74280408542247
maxdepth= 13
test f1
0.6666666666666665
train f1
0.747896540978498
maxdepth= 14
test f1
0.6608695652173913
train f1
0.7457735247208931
```

```
In [122]: plt.plot(np.arange(1,15), f1_lst_test2, label='f1 of testset')
          plt.plot(np.arange(1,15), f1_lst_train2, label='f1 of trainset')
          plt.xlabel('max_depth')
          plt.title('Double check the overfitting risk')
          plt.legend(loc='lower right')
          plt.show()
```



test3: stop_words: most common words in DS1+DS2 tweets

```
In [123]: stop_w = [i[0] for i in Counter([word for sentence in X for word in sentence.split()
                                           if 'climate' not in word.lower()
                                           and word.isalpha()
                                           and len(word)>1]).most_common()[:30]]
          stop_w

Out[123]: ['the',
           'to',
           'RT',
           'of',
           'change',
           'is',
           'and',
           'in',
           'that',
           'on',
           'for',
           'are',
           'you',
           'we',
           'The',
           'it',
           'this',
           'about',
           'be',
           'by',
```

```
            'have',
            'not',
            'will',
            'our',
            'from',
            'as',
            'can',
            'with',
            'all',
            'We']
```

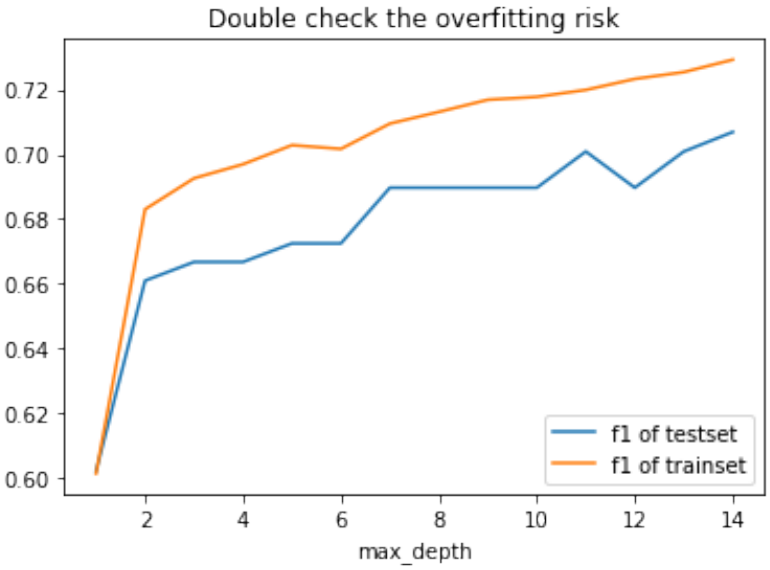
In [124]:
```
f1_lst_test3 = []
f1_lst_train3 = []
for d in range(1, 15):
    k_fold_evaluate(X, y, max_depth=d, min_samples_leaf=2,
                    stop_words=stop_w,
                    print_eval=False, overfit_risk=True)
    clf_tmp = joblib.load('ClimateTeam7PD2_maxdepth{}.pkl'.format(d))
    print('maxdepth=', d)
    # test
    y_pred = clf_tmp.predict(test_X)
    print('test f1')
    print(f1_score(y_pred=y_pred, y_true=test_y))
    f1_lst_test3.append(f1_score(y_pred=y_pred, y_true=test_y))
    # train_val
    y_pred = clf_tmp.predict(X)
    print('train f1')
    print(f1_score(y_pred=y_pred, y_true=y))
    f1_lst_train3.append(f1_score(y_pred=y_pred, y_true=y))
```

```
maxdepth= 1
test f1
0.6019417475728155
train f1
0.6012009890498058
maxdepth= 2
test f1
0.6608695652173913
train f1
0.6829733163913596
maxdepth= 3
test f1
0.6666666666666666
train f1
0.6925750394944707
maxdepth= 4
test f1
0.6666666666666666
```

```
train f1
0.6969124133585382
maxdepth= 5
test f1
0.6724137931034483
train f1
0.70282131661442
maxdepth= 6
test f1
0.6724137931034483
train f1
0.7016661427224143
maxdepth= 7
test f1
0.6896551724137931
train f1
0.7094954559699153
maxdepth= 8
test f1
0.6896551724137931
train f1
0.7131249999999999
maxdepth= 9
test f1
0.6896551724137931
train f1
0.716875
maxdepth= 10
test f1
0.6896551724137931
train f1
0.7177722152690864
maxdepth= 11
test f1
0.7008547008547009
train f1
0.7199248120300753
maxdepth= 12
test f1
0.6896551724137931
train f1
0.7233238904627006
maxdepth= 13
test f1
0.7008547008547009
train f1
0.725434439178515
maxdepth= 14
```

```
test f1
0.706896551724138
train f1
0.7292782855341946
```

```
In [125]: plt.plot(np.arange(1,15), f1_lst_test3, label='f1 of testset')
          plt.plot(np.arange(1,15), f1_lst_train3, label='f1 of trainset')
          plt.xlabel('max_depth')
          plt.title('Double check the overfitting risk')
          plt.legend(loc='lower right')
          plt.show()
```

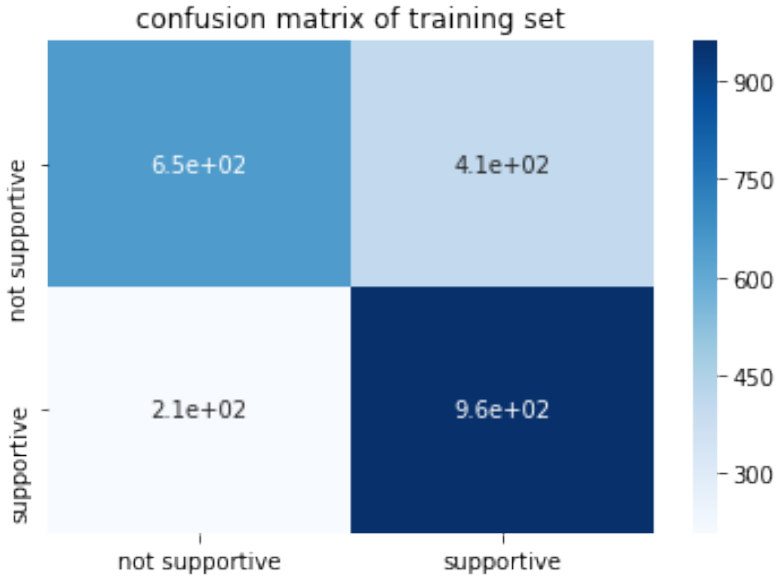


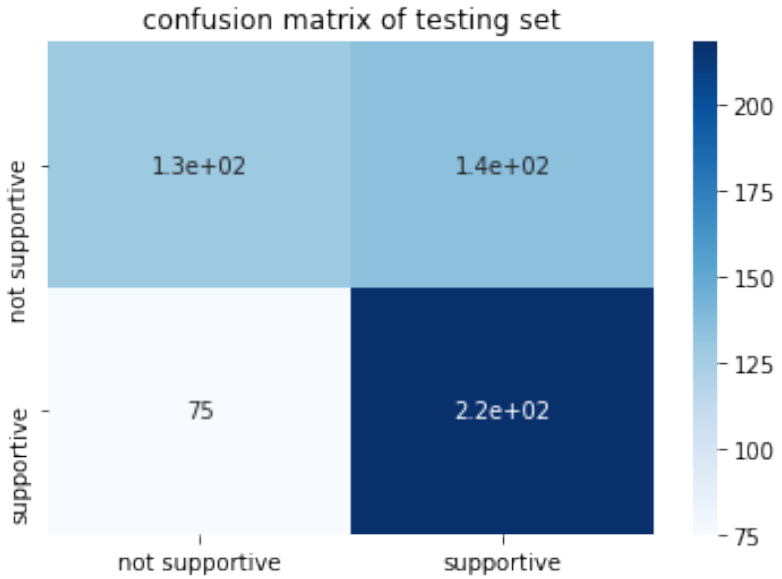
Final result

```
In [126]: k_fold_evaluate(X, y, max_depth=15, min_samples_leaf=2,
                          stop_words=stop_w,
                          print_eval=True, overfit_risk=False)
```

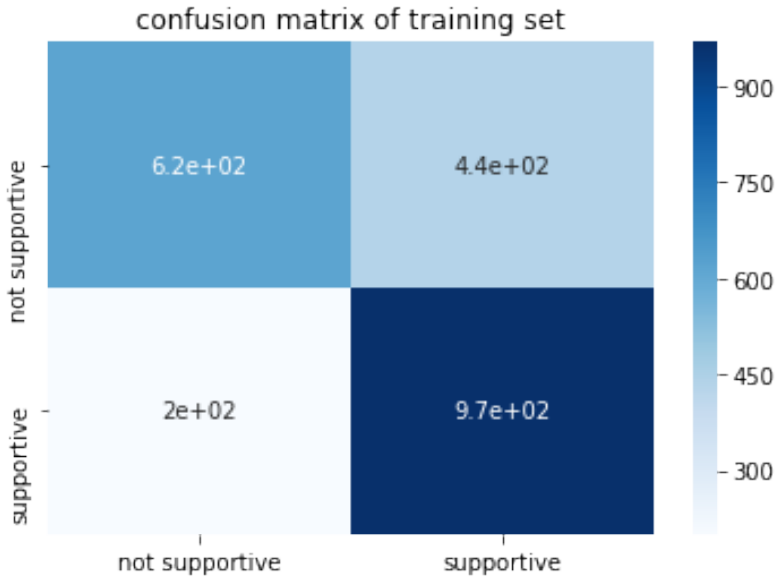
```
Fold: 1
Accuracy Score: 0.6229802513464991
Precision Score: 0.6175637393767706
Recall Score: 0.7440273037542662
f1 Score: 0.6749226006191951
confusion_matrix of training set is:
 [[649 407]
 [209 961]]
```

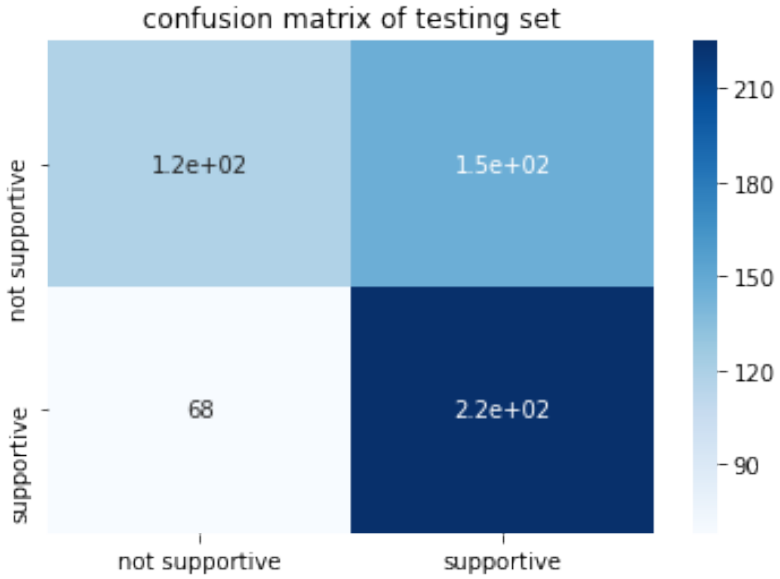
```
confusion_matrix of testing set is:
 [[129 135]
 [ 75 218]]

             precision    recall  f1-score   support

          0       0.63      0.49      0.55       264
          1       0.62      0.74      0.67       293

avg / total       0.62      0.62      0.62       557
```





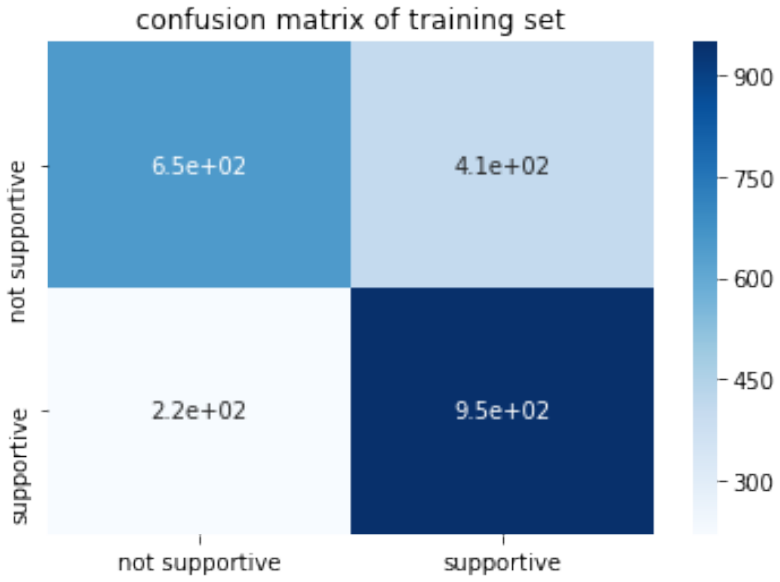

```
Fold: 2
Accuracy Score: 0.6157989228007181
Precision Score: 0.6064690026954178
Recall Score: 0.7679180887372014
f1 Score: 0.6777108433734939
confusion_matrix of training set is:
 [[619 437]
 [200 970]]

confusion_matrix of testing set is:
 [[118 146]
 [ 68 225]]

              precision    recall  f1-score   support

           0       0.63      0.45      0.52       264
           1       0.61      0.77      0.68       293

avg / total       0.62      0.62      0.61       557
```

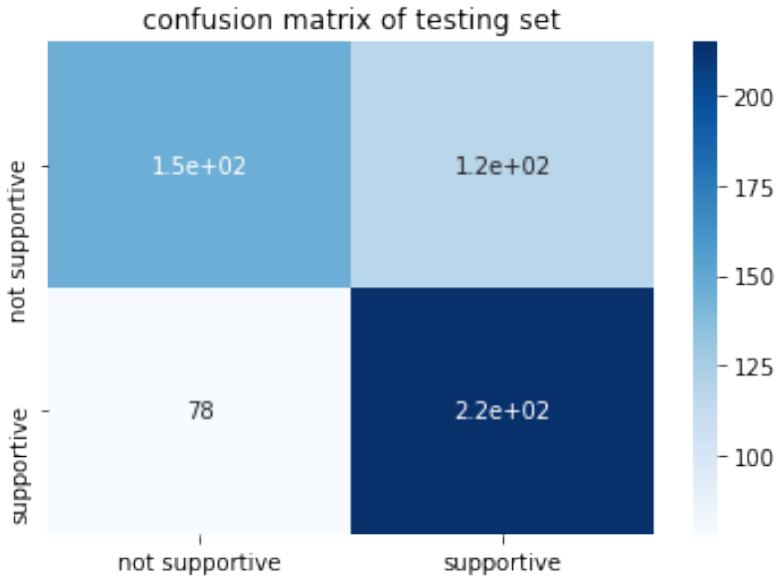




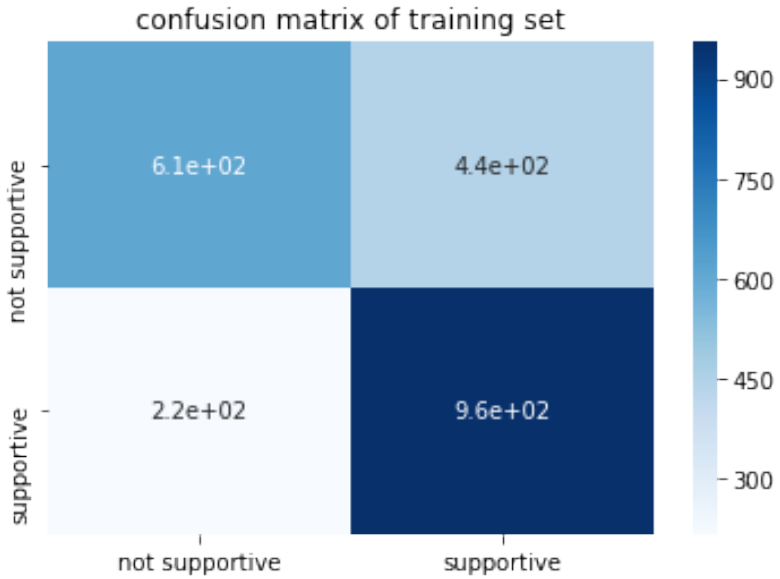

```
Fold: 3
Accuracy Score: 0.6481149012567325
Precision Score: 0.6456456456456456
Recall Score: 0.7337883959044369
f1 Score: 0.6869009584664537
confusion_matrix of training set is:
```

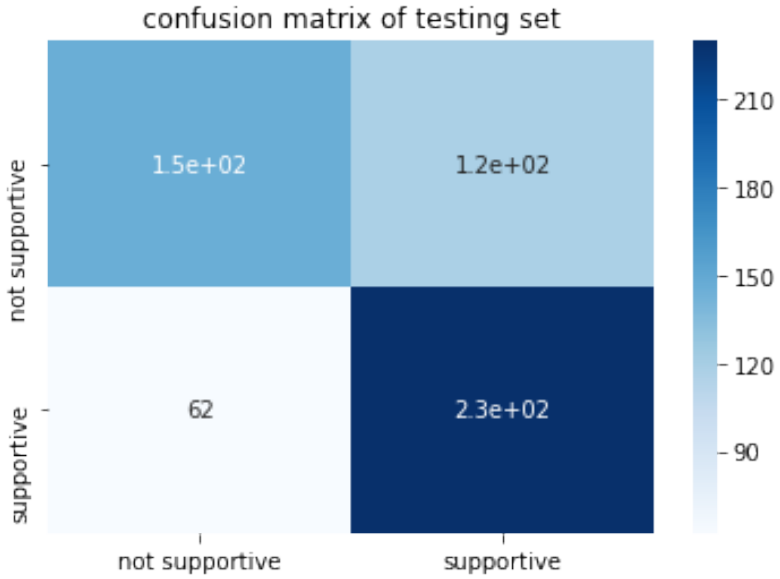
```
 [[649 407]
 [220 950]]

confusion_matrix of testing set is:
 [[146 118]
 [ 78 215]]

             precision    recall  f1-score   support

          0       0.65      0.55      0.60       264
          1       0.65      0.73      0.69       293

avg / total       0.65      0.65      0.64       557
```





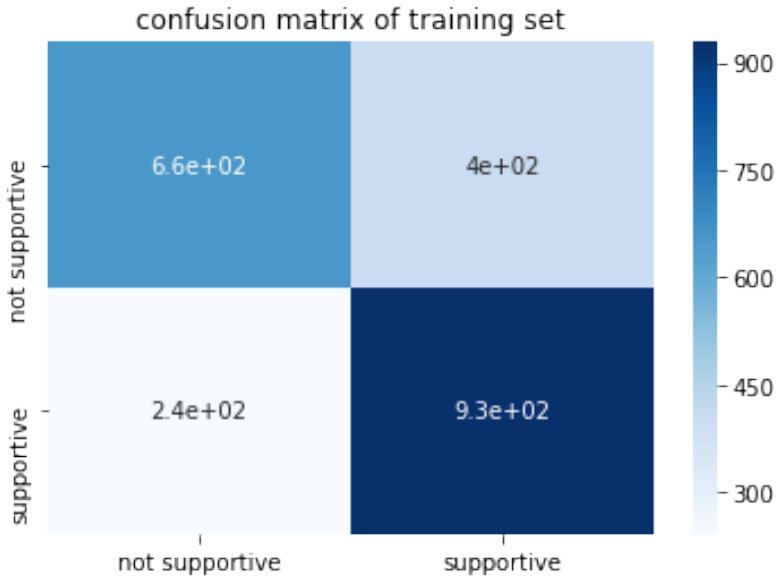

```
Fold: 4
Accuracy Score: 0.6762589928057554
Precision Score: 0.6609195402298851
Recall Score: 0.7876712328767124
f1 Score: 0.71875
confusion_matrix of training set is:
 [[612 444]
 [216 955]]

confusion_matrix of testing set is:
 [[146 118]
 [ 62 230]]

              precision    recall  f1-score   support

           0       0.70      0.55      0.62       264
           1       0.66      0.79      0.72       292

avg / total       0.68      0.68      0.67       556
```

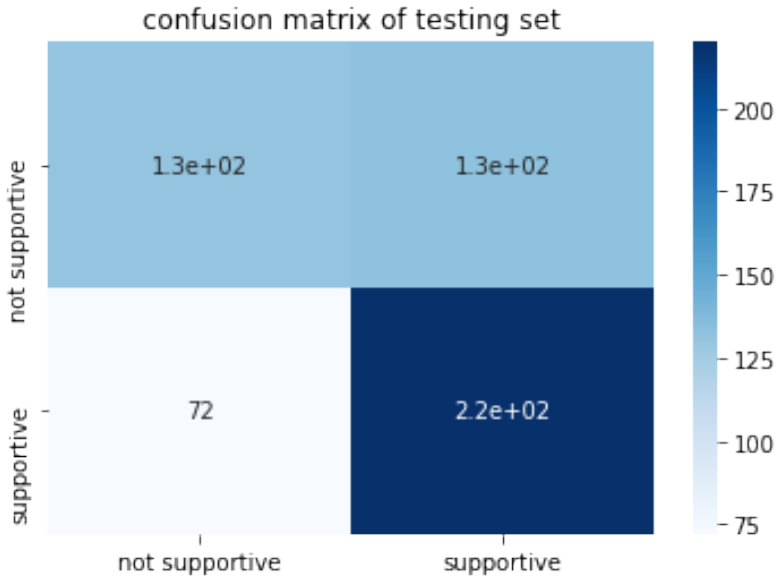





```
Fold: 5
Accuracy Score: 0.6312949640287769
Precision Score: 0.623229461756374
Recall Score: 0.7534246575342466
f1 Score: 0.6821705426356589
confusion_matrix of training set is:
```

```
 [[655 401]
 [242 929]]

confusion_matrix of testing set is:
 [[131 133]
 [ 72 220]]

             precision    recall  f1-score   support

          0       0.65      0.50      0.56       264
          1       0.62      0.75      0.68       292

avg / total       0.63      0.63      0.62       556
```





Out[126]:

	accuracy	precision	recall	f1
0	0.622980	0.617564	0.744027	0.674923
1	0.615799	0.606469	0.767918	0.677711
2	0.648115	0.645646	0.733788	0.686901
3	0.676259	0.660920	0.787671	0.718750
4	0.631295	0.623229	0.753425	0.682171

In [172]:
```
clf2 = joblib.load('ClimateTeam7PD2.pkl')
```

In [215]:
```
df1 = ds.Table.read_table('Climate1SupportiveLevel.csv', sep=',')
df2 = ds.Table.read_table('ClimateBalancedDS2.csv', sep=',')
df = df1.append(df2)
X = list(df['Text'])
y = list(df['Support'])
y_pred = clf_tmp.predict(X)
f1_score(y, y_pred)
```

Out[215]: 0.728488902401946