Course Project Logistic Regression Model

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Exploratory Data Analysis

Import Libraries

In [67]:

```
#All libraries used in this project are listed here
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

import nltk
from nltk.stem import WordNetLemmatizer
from nltk.tokenize import RegexpTokenizer
from nltk.corpus import stopwords

import re
from bs4 import BeautifulSoup

from sklearn.feature_extraction.text import CountVectorizer,TfidfVectorizer
from sklearn.pipeline import Pipeline
from sklearn.model_selection import train_test_split, GridSearchCV,cross_val_score
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import confusion_matrix, classification_report
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score, make_scorer, recall_score, precision_score,ac
from sklearn.metrics import confusion_matrix, plot_confusion_matrix
from sklearn.ensemble import RandomForestClassifier, ExtraTreesClassifier
from sklearn.metrics import confusion_matrix, plot_confusion_matrix, accuracy_score, plo
```

Open Scraped Datasets

The jupytyer notebooks for scraping are 'reddit-scrape.ipynb' and 'wallstreetbets-scrape.ipynb'

In [68]:

```
investing_df = pd.read_csv('datasets/investing.csv')
stockmarket_df = pd.read_csv('datasets/stockmarket.csv')
```

r/investing

In [69]:

```
investing_df.shape
```

Out[69]:

```
(7995, 75)
```

In [70]:

```
investing_df.iloc[investing_df.shape[0]-1]['created_utc']

# GMT: Friday, July 8, 2022 9:18:46 AM
```

Out[70]:

```
1657271926
```

In [71]:

```
investing_df=investing_df[['subreddit', 'author', 'selftext', 'title']]
investing_df.head()
```

Out[71]:

	subreddit	author	selftext	title
0	investing	HomeInvading	Hey guys, I'm a 22 year old male, I grew up wi...	Help a young man out would ya?
1	investing	ocean-airseashell10	[removed]	Treasury bonds is it a good idea to buy
2	investing	ocean-airseashell10	[removed]	How to buy treasury bonds? Is treasury's direc...
3	investing	iamjokingiamserious	[removed]	Early Exercise of Stock Options
4	investing	jamesterryburke01	Hello Redditors 👋 \n\nI work as a Investment C...	Alternative Investments -

In [72]:

```
investing_df1=investing_df[['subreddit', 'selftext']]
investing_df2=investing_df[['subreddit', 'title']]

investing_df1.rename(columns={'selftext':'Text'},inplace=True)
investing_df2.rename(columns={'title':'Text'},inplace=True)
```

```
C:\Users\redoc\AppData\Local\Temp\ipykernel_98540\2530647326.py:4: Setting
WithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-doc
s/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (https://
pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-
view-versus-a-copy)
  investing_df1.rename(columns={'selftext':'Text'},inplace=True)
C:\Users\redoc\AppData\Local\Temp\ipykernel_98540\2530647326.py:5: Setting
WithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-doc
s/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (https://
pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-
view-versus-a-copy)
  investing_df2.rename(columns={'title':'Text'},inplace=True)
```

In [73]:

```
investing_df = pd.concat([investing_df1, investing_df2], ignore_index=True,axis=0)
investing_df.head()
```

Out[73]:

	subreddit	Text
0	investing	Hey guys, I'm a 22 year old male, I grew up wi...
1	investing	[removed]
2	investing	[removed]
3	investing	[removed]
4	investing	Hello Redditors 👋 \n\nI work as a Investment C...

In [74]:

```
investing_df.shape
```

Out[74]:

```
(15990, 2)
```

r/stockmarket

In [75]:

```
stockmarket_df.shape
```

Out[75]:

```
(7494, 81)
```

In [76]:

```
stockmarket_df.iloc[stockmarket_df.shape[0]-1]['created_utc']

# GMT: Wednesday, July 13, 2022 2:13:58 AM
```

Out[76]:

```
1657678438
```

In [77]:

```
stockmarket_df=stockmarket_df[['subreddit', 'selftext', 'title']]
stockmarket_df.head()
```

Out[77]:

	subreddit	selftext	title
0	StockMarket	NaN	Looking for the next exogenous event that take...
1	StockMarket	[Link to the full article (4 min read)](https:...	China stocks notch trillion-dollar gain on hop...
2	StockMarket	NaN	Get ready for some economic news and company e...
3	StockMarket	NaN	Market Recap! Bear Market Blues! Palantir (PLT...
4	StockMarket	NaN	Why it's not smart to rely on the RSI divergence

In [78]:

```
stockmarket_df.shape
```

Out[78]:

```
(7494, 3)
```

In [79]:

```
stockmarket_df1=stockmarket_df[['subreddit', 'selftext']]
stockmarket_df2=stockmarket_df[['subreddit', 'title']]

stockmarket_df1.rename(columns={'selftext':'Text'},inplace=True)
stockmarket_df2.rename(columns={'title':'Text'},inplace=True)
```

```
C:\Users\redoc\AppData\Local\Temp\ipykernel_98540\961984385.py:4: SettingW
ithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-doc
s/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (https://
pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-
view-versus-a-copy)
  stockmarket_df1.rename(columns={'selftext':'Text'},inplace=True)
C:\Users\redoc\AppData\Local\Temp\ipykernel_98540\961984385.py:5: SettingW
ithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-doc
s/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (https://
pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-
view-versus-a-copy)
  stockmarket_df2.rename(columns={'title':'Text'},inplace=True)
```

In [80]:

```
stockmarket_df = pd.concat([stockmarket_df1, stockmarket_df2], ignore_index=True,axis=0)
stockmarket_df.head()
```

Out[80]:

	subreddit	Text
0	StockMarket	NaN
1	StockMarket	[Link to the full article (4 min read)](https:...
2	StockMarket	NaN
3	StockMarket	NaN
4	StockMarket	NaN

In [81]:

```
stockmarket_df.shape
```

Out[81]:

```
(14988, 2)
```

Final Cleaning

Handling Missing Values

In [ ]:

```
#investing_df['selftext']=investing_df['selftext'].fillna('')
#stockmarket_df['selftext']=stockmarket_df['selftext'].fillna('')
```

In [82]:

```
investing_df=investing_df.dropna()
stockmarket_df=stockmarket_df.dropna()
```

In [83]:

```
investing_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 15964 entries, 0 to 15989
Data columns (total 2 columns):
 #   Column     Non-Null Count  Dtype 
---  ------     --------------  ----- 
 0   subreddit  15964 non-null  object
 1   Text       15964 non-null  object
dtypes: object(2)
memory usage: 374.2+ KB
```

In [84]:

```
stockmarket_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 11181 entries, 1 to 14987
Data columns (total 2 columns):
 #   Column     Non-Null Count  Dtype 
---  ------     --------------  ----- 
 0   subreddit  11181 non-null  object
 1   Text       11181 non-null  object
dtypes: object(2)
memory usage: 262.1+ KB
```

Concatenate both Dataframes

In [85]:

```
df = pd.concat([investing_df,stockmarket_df],ignore_index=True)
```

In [86]:

```
df.shape
```

Out[86]:

```
(27145, 2)
```

In [87]:

```
df['subreddit'].value_counts()
```

Out[87]:

```
investing      15964
StockMarket    11181
Name: subreddit, dtype: int64
```

In [88]:

```
df.head()
```

Out[88]:

	subreddit	Text
0	investing	Hey guys, I'm a 22 year old male, I grew up wi...
1	investing	[removed]
2	investing	[removed]
3	investing	[removed]
4	investing	Hello Redditors 👋 \n\nI work as a Investment C...

Lowercase

In [89]:

```
df['Text']=[c.lower() for c in df['Text']]
```

Remove Non Letters

In [90]:

```
df['Text']=df['Text'].map(lambda x: re.sub("[^a-zA-Z]", " ", x))
```

Remove Stop Words

In [91]:

```
def remove_stop_words(text):
    stops = stopwords.words('english')
    stops=set(stops)
    text = " ".join([word for word in text.split() if word not in (stops)])
    # text = [w for w in text if not w in stops]

    return text
```

In [92]:

```
df['Text']=df['Text'].map(lambda x: remove_stop_words(x))
```

Hot Encode Target Vector

In [93]:

```
df['subreddit']=df['subreddit'].map({'investing': 0, 'StockMarket': 1})
```

In [94]:

```
df.head()
```

Out[94]:

	subreddit	Text
0	0	hey guys year old male grew greatest backgroun...
1	0	removed
2	0	removed
3	0	removed
4	0	hello redditors work investment consultant bou...

Remove Rows where Text is 'removed'

In [95]:

```
df=df[df['Text'].str.contains('removed')==False]
```

In [96]:

```
df.head()
```

Out[96]:

	subreddit	Text
0	0	hey guys year old male grew greatest backgroun...
4	0	hello redditors work investment consultant bou...
7	0	back around ish remember reading ad charles sc...
11	0	greetings everyone general quick question look...
18	0	coming share mind bogglingly low valuation par...

In [97]:

```
X=df['Text']
y=df['subreddit']
```

In [98]:

```
y.value_counts(normalize = True)
```

Out[98]:

```
0    0.5521
1    0.4479
Name: subreddit, dtype: float64
```

In [99]:

```
# Split the data into the training and testing sets.
X_train, X_test, y_train, y_test = train_test_split(X,
                                                    y,
                                                    test_size=0.33,
                                                    stratify=y, # stratify means the pro
                                                    random_state=42)
```

Count Vectorizer

In [100]:

```
# Instantiate a CountVectorizer with the default hyperparameters.
cvec = CountVectorizer()
```

In [101]:

```
X_train
```

Out[101]:

```
25325          regencell rgc performing stock among us ipo
26350    help understanding impairment calculation mstr...
14194                              beginner investor start
366      turning days saving money invest wondering goo...
12184                          new discord server investing
                               ...
11331                            right idea passive income
15799                                help boy graduate lfg
4668     hey first time posting working weekend job cou...
15879                        investing life insurance money
16345    elon musk friday p et close deal twitter trial...
Name: Text, Length: 12924, dtype: object
```

In [102]:

```
# Fit the vectorizer on our corpus.
cvec.fit(X_train)
```

Out[102]:

```
CountVectorizer()
```

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

In [103]:

```
# Transform the corpus.
X_train = cvec.transform(X_train)
# transform creates the vector of words
```

In [104]:

```
X_train.shape
```

Out[104]:

```
(12924, 23993)
```

In [105]:

```
print(X_train)
```

```
  (0, 795)      1
  (0, 10963)    1
  (0, 15359)    1
  (0, 17258)    1
  (0, 17790)    1
  (0, 19966)    1
  (0, 22271)    1
  (1, 837)      1
  (1, 2929)     1
  (1, 6361)     1
  (1, 9629)     1
  (1, 10318)    1
  (1, 13548)    1
  (1, 21951)    1
  (2, 1925)     1
  (2, 10905)    1
  (2, 19839)    1
  (3, 961)      1
  (3, 1032)     1
  (3, 2401)     1
  (3, 5047)     1
  (3, 5050)     1
  (3, 6653)     1
  (3, 7556)     1
  (3, 9020)     2
  :     :
  (12923, 21078)        1
  (12923, 21229)        2
  (12923, 21247)        4
  (12923, 21514)        8
  (12923, 21580)        1
  (12923, 21651)        1
  (12923, 21722)        10
  (12923, 21727)        2
  (12923, 21916)        1
  (12923, 22059)        3
  (12923, 22069)        1
  (12923, 22076)        2
  (12923, 22202)        1
  (12923, 22332)        4
  (12923, 22974)        1
  (12923, 23010)        1
  (12923, 23082)        1
  (12923, 23090)        2
  (12923, 23126)        1
  (12923, 23149)        1
  (12923, 23267)        1
  (12923, 23433)        1
  (12923, 23445)        5
  (12923, 23536)        3
  (12923, 23797)        1
```

In [106]:

```
cvec.get_feature_names()[1000:1010]
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\utils\deprecation.py:87: FutureWarning: Function get_feature_names
is deprecated; get_feature_names is deprecated in 1.0 and will be removed
in 1.2. Please use get_feature_names_out instead.
  warnings.warn(msg, category=FutureWarning)
```

Out[106]:

```
['apms',
 'apnews',
 'apo',
 'apocalypse',
 'apocalyptic',
 'apog',
 'apolitical',
 'apollo',
 'apologies',
 'apologize']
```

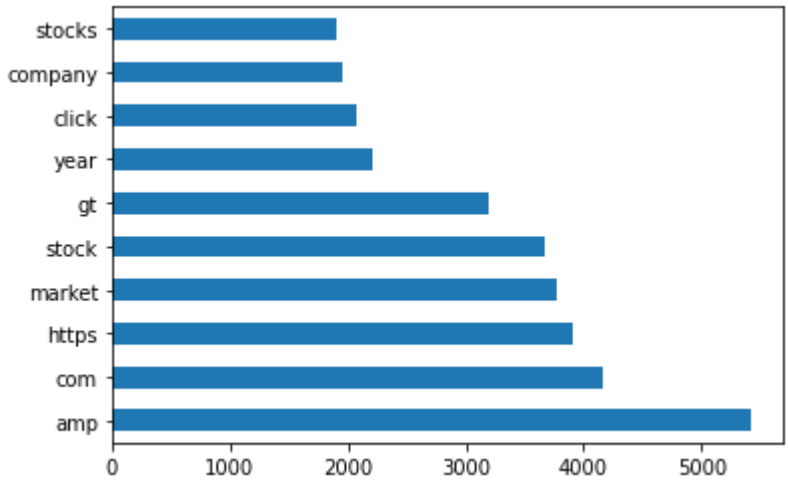
In [107]:

```
# Transform test
X_test = cvec.transform(X_test) # we fit the CountVectorizer data based on the X_Train a
```

In [108]:

```
# convert training data to dataframe
X_train_df = pd.DataFrame(X_train.todense(),
                          columns=cvec.get_feature_names()) # cvec is the CountVectorize

# plot top occuring words
X_train_df.sum().sort_values(ascending=False).head(10).plot(kind='barh'); # head(10) giv
```



Baseline Accuracy

In [109]:

```
y_test.value_counts(normalize=True)
```

Out[109]:

```
0    0.552152
1    0.447848
Name: subreddit, dtype: float64
```

Reinstantiate Train and Test Data

To avoid error of instantiating/fitting count vectorizer down below [IMPORTANT]

In [110]:

```
# Split the data into the training and testing sets.
X_train, X_test, y_train, y_test = train_test_split(X,
                                                    y,
                                                    test_size=0.33,
                                                    stratify=y, # stratify means the pro
                                                    random_state=42)
```

1. Logistic Regression with Count Vectorizer

In [111]:

```
pipe = Pipeline([('cvec', CountVectorizer()),
                 ('lr', LogisticRegression(solver='lbfgs'))
                ])
```

In [112]:

```
cross_val_score(pipe, X_train, y_train, cv=5)
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs failed to
converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown i
n:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sc
ikit-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-reg
ression (https://scikit-learn.org/stable/modules/linear_model.html#logisti
c-regression)
  n_iter_i = _check_optimize_result(
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs failed to
converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown i
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    https://scikit-learn.org/stable/modules/preprocessing.html (https://sc
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Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-reg
ression (https://scikit-learn.org/stable/modules/linear_model.html#logisti
c-regression)
  n_iter_i = _check_optimize_result(
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs failed to
converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown i
n:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sc
ikit-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-reg
ression (https://scikit-learn.org/stable/modules/linear_model.html#logisti
c-regression)
  n_iter_i = _check_optimize_result(
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs failed to
converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown i
n:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sc
ikit-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-reg
ression (https://scikit-learn.org/stable/modules/linear_model.html#logisti
c-regression)
  n_iter_i = _check_optimize_result(
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs failed to
converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

```
Increase the number of iterations (max_iter) or scale the data as shown i
n:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sc
ikit-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-reg
ression (https://scikit-learn.org/stable/modules/linear_model.html#logisti
c-regression)
  n_iter_i = _check_optimize_result(
```

Out[112]:

```
array([0.73926499, 0.72533849, 0.70870406, 0.7237911 , 0.73916409])
```

In [113]:

```
# ii. Fit into model
pipe.fit(X_train, y_train)

# Training score
print(pipe.score(X_train, y_train))

# Test score
print(pipe.score(X_test, y_test))
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs failed to
converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown i
n:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sc
ikit-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-reg
ression (https://scikit-learn.org/stable/modules/linear_model.html#logisti
c-regression)
  n_iter_i = _check_optimize_result(

0.8995666976168369
0.7386113729186302
```

GridSearch

In [114]:

```
pipe_params = {
    'cvec__max_features': [2500, 3000, 3500],
    'cvec__min_df': [0.05], # change to percentage
    'cvec__max_df': [0.9],
    'cvec__ngram_range': [(1,2)],
    "lr__C": [10,2,1.25] # np.logspace() # 1,1.25,num=5
}
scorers = {
    'precision_score': make_scorer(precision_score),
    'recall_score': make_scorer(recall_score),
    'accuracy_score': make_scorer(accuracy_score)
}
#scorers dictionary allows us to prioritize which score we want for the model. Then we r
gs_count_logreg = GridSearchCV(pipe,param_grid=pipe_params,scoring=scorers,refit='accura

# https://stackoverflow.com/questions/24005762/understanding-the-ngram-range-argument-in
# https://stackoverflow.com/questions/27697766/understanding-min-df-and-max-df-in-scikit
```

This gridsearch took 11 min 6.3 sec

In [115]:

```
gs_count_logreg.fit(X_train, y_train)
```

Out[115]:

```
GridSearchCV(cv=5,
             estimator=Pipeline(steps=[('cvec', CountVectorizer()),
                                       ('lr', LogisticRegression())]),
             param_grid={'cvec__max_df': [0.9],
                         'cvec__max_features': [2500, 3000, 3500],
                         'cvec__min_df': [0.05], 'cvec__ngram_range': [(1,
2)],
                         'lr__C': [10, 2, 1.25]},
             refit='accuracy_score',
             scoring={'accuracy_score': make_scorer(accuracy_score),
                      'precision_score': make_scorer(precision_score),
                      'recall_score': make_scorer(recall_score)})
```

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

In [116]:

```
print(gs_count_logreg.best_score_)
gs_count_logreg.best_params_
```

```
0.6108786401662366
```

Out[116]:

```
{'cvec__max_df': 0.9,
 'cvec__max_features': 2500,
 'cvec__min_df': 0.05,
 'cvec__ngram_range': (1, 2),
 'lr__C': 2}
```

In [117]:

```
gs_count_logreg.score(X_train, y_train)
```

Out[117]:

```
0.6142061281337048
```

In [118]:

```
gs_count_logreg.score(X_test, y_test)
```

Out[118]:

```
0.6176562990889098
```

Try Again but with different C values for Logistic Regression

In [119]:

```
for i in np.logspace(0.096,1,num=10):
    print(1/i)
```

```
0.8016780633876791
0.6361441760824124
0.504790428034794
0.4005591590962541
0.31785000472481023
0.25221898740626414
0.20013974095522713
0.15881403823537268
0.12602144191976725
0.1
```

In [120]:

```
pipe_params = {
    'cvec__max_features': [2500, 3000, 3500],
    'cvec__min_df': [0.05],
    'cvec__max_df': [.8,.9, .95],
    'cvec__ngram_range': [(1,1), (1,2)],
    "lr__C": np.logspace(0.096,1,num=10) # np.logspace()
}
scorers = {
    'precision_score': make_scorer(precision_score),
    'recall_score': make_scorer(recall_score),
    'accuracy_score': make_scorer(accuracy_score)
}
#scorers dictionary allows us to prioritize which score we want for the model. Then we r
gs_count_logreg2 = GridSearchCV(pipe,param_grid=pipe_params,scoring=scorers,refit='accur
```

This gridsearch took 15 min

In [121]:

```
gs_count_logreg2.fit(X_train, y_train)
```

Out[121]:

```
GridSearchCV(cv=5,
             estimator=Pipeline(steps=[('cvec', CountVectorizer()),
                                       ('lr', LogisticRegression())]),
             param_grid={'cvec__max_df': [0.8, 0.9, 0.95],
                         'cvec__max_features': [2500, 3000, 3500],
                         'cvec__min_df': [0.05],
                         'cvec__ngram_range': [(1, 1), (1, 2)],
                         'lr__C': array([ 1.24738351,  1.57197069,  1.9810
2013,  2.49651013,  3.14613807,
        3.96480856,  4.99650892,  6.29667258,  7.93515758, 10.        ])},
             refit='accuracy_score',
             scoring={'accuracy_score': make_scorer(accuracy_score),
                      'precision_score': make_scorer(precision_score),
                      'recall_score': make_scorer(recall_score)})
```

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

In [122]:

```
print(gs_count_logreg2.best_score_)
gs_count_logreg2.best_params_
```

```
0.6108786401662366
```

Out[122]:

```
{'cvec__max_df': 0.8,
 'cvec__max_features': 2500,
 'cvec__min_df': 0.05,
 'cvec__ngram_range': (1, 1),
 'lr__C': 1.247383514242943}
```

In [123]:

```
gs_count_logreg2.score(X_train, y_train)
```

Out[123]:

```
0.6142061281337048
```

In [124]:

```
gs_count_logreg2.score(X_test, y_test)
```

Out[124]:

```
0.6176562990889098
```

In [125]:

```
pipe_params = {
    'cvec__max_features': [2500, 3000, 3500],
    'cvec__min_df': [1, 2],
    'cvec__max_df': [.8,.9, .95],
    'cvec__ngram_range': [(1,1), (1,2)],
    "lr__C": np.logspace(1,1.25,num=5) # np.logspace()
}
scorers = {
    'precision_score': make_scorer(precision_score),
    'recall_score': make_scorer(recall_score),
    'accuracy_score': make_scorer(accuracy_score)
}
#scorers dictionary allows us to prioritize which score we want for the model. Then we r
gs_count_logreg3 = GridSearchCV(pipe,param_grid=pipe_params,scoring=scorers,refit='accur
```

This gridsearch took 16 min 25.4 sec

In [126]:

```
gs_count_logreg3.fit(X_train, y_train)
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-package
s\sklearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs fail
ed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown
in:
    https://scikit-learn.org/stable/modules/preprocessing.html (http
s://scikit-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression (https://scikit-learn.org/stable/modules/linear_model.html#l
ogistic-regression)
  n_iter_i = _check_optimize_result(
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-package
s\sklearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs fail
ed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

In [127]:

```
print(gs_count_logreg3.best_score_)
gs_count_logreg3.best_params_
```

```
0.7034983322454503
```

Out[127]:

```
{'cvec__max_df': 0.8,
 'cvec__max_features': 3500,
 'cvec__min_df': 2,
 'cvec__ngram_range': (1, 2),
 'lr__C': 11.547819846894582}
```

In [128]:

```
gs_count_logreg3.score(X_train, y_train)
```

Out[128]:

```
0.8382079851439183
```

In [129]:

```
gs_count_logreg3.score(X_test, y_test)
```

Out[129]:

```
0.7200754005655042
```

BOOLEAN MASKING ON DATAFRAME

WITH ACTUAL TEST TARGET AND PREDICTED VALUES TO FIND OUT THE FALSE POSITIVES AND FALSE NEGATIVES

In [131]:

```
preds = gs_count_logreg.predict(X_test)
```

In [140]:

```
preds = pd.Series(preds)

print(type(preds))
preds
```

```
<class 'pandas.core.series.Series'>
```

Out[140]:

```
0       0
1       0
2       0
3       1
4       0
       ..
6361    0
6362    0
6363    0
6364    1
6365    1
Length: 6366, dtype: int64
```

In [137]:

```
print(type(X_test))

X_test.head()
```

```
<class 'pandas.core.series.Series'>
```

Out[137]:

```
8406           traditional roth tax bracket actually lower
14781          daily general discussion advice thread july
7471     hi wondering would good place put pitch invest...
25723    bed bath amp beyond inc bbby one heavily short...
20041                               go well morning coffee
Name: Text, dtype: object
```

In [138]:

```
print(type(y_test))

y_test
```

```
<class 'pandas.core.series.Series'>
```

Out[138]:

```
8406     0
14781    0
7471     0
25723    1
20041    1
        ..
13748    0
21637    1
20291    1
14025    0
22170    1
Name: subreddit, Length: 6366, dtype: int64
```

In [142]:

```
df = pd.concat([X_test, y_test], axis=1).reset_index()
df
```

Out[142]:

	index	Text	subreddit
0	8406	traditional roth tax bracket actually lower	0
1	14781	daily general discussion advice thread july	0
2	7471	hi wondering would good place put pitch invest...	0
3	25723	bed bath amp beyond inc bbby one heavily short...	1
4	20041	go well morning coffee	1
...	...	...	...
6361	13748	drought hitting ca italy france hard	0
6362	21637	needed become hedge fund manager analyst	1
6363	20291	u gdp accelerated pace q better expected growt...	1
6364	14025	rate portfolio individual stocks	0
6365	22170	fake tweet temporarily wiped us billion stock ...	1

6366 rows × 3 columns

In [143]:

```
df = pd.concat([df, preds], axis=1).reset_index()
# df.drop(['level_0','index'],axis=1, inplace=True)
df
```

Out[143]:

	level_0	index	Text	subreddit	0
0	0	8406	traditional roth tax bracket actually lower	0	0
1	1	14781	daily general discussion advice thread july	0	0
2	2	7471	hi wondering would good place put pitch invest...	0	0
3	3	25723	bed bath amp beyond inc bbby one heavily short...	1	1
4	4	20041	go well morning coffee	1	0
...	...	...	...	...	...
6361	6361	13748	drought hitting ca italy france hard	0	0
6362	6362	21637	needed become hedge fund manager analyst	1	0
6363	6363	20291	u gdp accelerated pace q better expected growt...	1	0
6364	6364	14025	rate portfolio individual stocks	0	1
6365	6365	22170	fake tweet temporarily wiped us billion stock ...	1	1

6366 rows × 5 columns

In [144]:

```
df.drop(['level_0','index'],axis=1, inplace=True)
df
```

Out[144]:

	Text	subreddit	0
0	traditional roth tax bracket actually lower	0	0
1	daily general discussion advice thread july	0	0
2	hi wondering would good place put pitch invest...	0	0
3	bed bath amp beyond inc bbby one heavily short...	1	1
4	go well morning coffee	1	0
...	...	...	...
6361	drought hitting ca italy france hard	0	0
6362	needed become hedge fund manager analyst	1	0
6363	u gdp accelerated pace q better expected growt...	1	0
6364	rate portfolio individual stocks	0	1
6365	fake tweet temporarily wiped us billion stock ...	1	1

6366 rows × 3 columns

In [147]:

```
df.columns
```

Out[147]:

```
Index(['Text', 'subreddit', 0], dtype='object')
```

In [151]:

```
false_positive_mask = (df['subreddit']== 0)&(df[0]== 1)
false_negative_mask = (df['subreddit']== 1)&(df[0]== 0)
```

False Positives List

In [152]:

```
df[false_positive_mask]['Text']
```

Out[152]:

```
14      anyone else think bonds looking undervalued fa...
27      cash roth holding gunpowder market bottoms try...
29                          general thoughts stock market
42      batch single stocks feel confident future span...
92                                 much make penny stocks
                              ...
6302                        worth entering uk gilt market
6334                        market catalysts coming month
6344    could help understand advice got bank stock po...
6354    work contributes think allowed contribute spon...
6364                      rate portfolio individual stocks
Name: Text, Length: 535, dtype: object
```

False Negatives List

In [153]:

```
df[false_negative_mask]['Text']
```

Out[153]:

```
4                                  go well morning coffee
7       tlry elon musk buys billion stake tlry inc htt...
21                     gacha characters mettaton kissing
22      two americans sent prison stealing crypto sim ...
23      wall street creates counterfeit shares amc gam...
                              ...
6352        twitter asks musk turn texts first six months
6353    letting financially literate folks test skills...
6355    cranium proof gifted gene gift god medici ethe...
6362              needed become hedge fund manager analyst
6363    u gdp accelerated pace q better expected growt...
Name: Text, Length: 1899, dtype: object
```

Accuracy Check [Logistic Regression with Count Vectorizer]

Pipeline Accuracy

In [154]:

```
# Get predictions
preds = pipe.predict(X_test)

# Save confusion matrix values
tn, fp, fn, tp = confusion_matrix(y_test, preds).ravel()
```

In [155]:

```
confusion_matrix(y_test, preds)
```

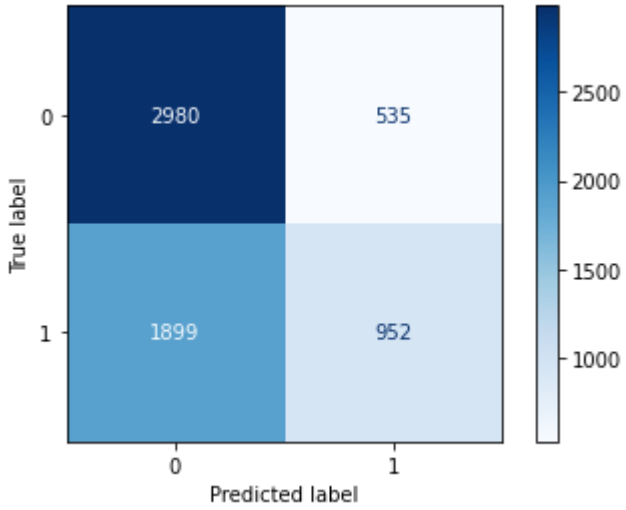
Out[155]:

```
array([[2696,  819],
       [ 845, 2006]], dtype=int64)
```

In [156]:

```
# View confusion matrix

plot_confusion_matrix(gs_count_logreg, X_test, y_test, cmap='Blues', values_format='d');
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\utils\deprecation.py:87: FutureWarning: Function plot_confusion_mat
rix is deprecated; Function `plot_confusion_matrix` is deprecated in 1.0 a
nd will be removed in 1.2. Use one of the class methods: ConfusionMatrixDi
splay.from_predictions or ConfusionMatrixDisplay.from_estimator.
  warnings.warn(msg, category=FutureWarning)
```



In [157]:

```
# Calculate the specificity

spec = tn / (tn + fp)

print('Specificity:', spec)
```

```
Specificity: 0.7669985775248933
```

In [158]:

```
# Calculate the sensitivity

sens = tp/(tp+fn)

print('Sensitivity:', sens)
```

```
Sensitivity: 0.7036127674500176
```

In [159]:

```
accuracy = (tp+tn)/(tp+fp+tn+fn)

print('Accuracy:', accuracy)
```

```
Accuracy: 0.7386113729186302
```

Gridsearch Accuracy

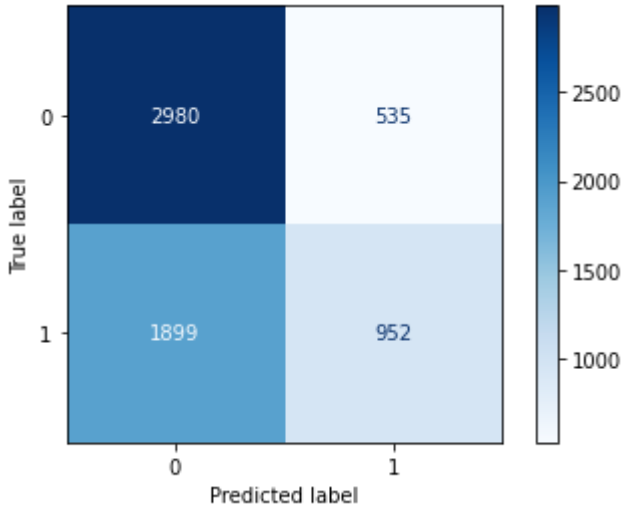
In [160]:

```
# Get predictions
preds = gs_count_logreg.predict(X_test)

# Save confusion matrix values
tn, fp, fn, tp = confusion_matrix(y_test, preds).ravel()
```

In [161]:

```
# View confusion matrix

plot_confusion_matrix(gs_count_logreg, X_test, y_test, cmap='Blues', values_format='d');
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\utils\deprecation.py:87: FutureWarning: Function plot_confusion_mat
rix is deprecated; Function `plot_confusion_matrix` is deprecated in 1.0 a
nd will be removed in 1.2. Use one of the class methods: ConfusionMatrixDi
splay.from_predictions or ConfusionMatrixDisplay.from_estimator.
  warnings.warn(msg, category=FutureWarning)
```



In [162]:

```
# Calculate the specificity

spec = tn / (tn + fp)

print('Specificity:', spec)
```

```
Specificity: 0.8477951635846372
```

In [163]:

```
# Calculate the sensitivity

sens = tp/(tp+fn)

print('Sensitivity:', sens)
```

```
Sensitivity: 0.33391792353560157
```

In [164]:

```
accuracy = (tp+tn)/(tp+fp+tn+fn)

print('Accuracy:', accuracy)
```

```
Accuracy: 0.6176562990889098
```

Error Analysis [Type 1 and Type 2 Errors]

https://www.datasciencecentral.com/understanding-type-i-and-type-ii-errors/ (https://www.datasciencecentral.com/understanding-type-i-and-type-ii-errors/)

How many Type I errors [FALSE POSITIVE] are there?

In [165]:

```
fp
```

Out[165]:

```
535
```

How many Type II errors [FALSE NEGATIVE] are there?

In [166]:

```
fn
```

Out[166]:

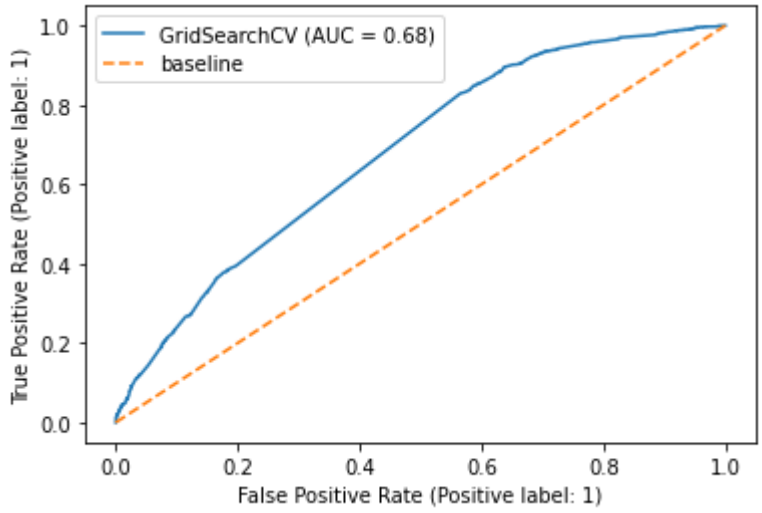
```
1899
```

Which error is worse (Type I vs Type II)?

In [167]:

```
plot_roc_curve(gs_count_logreg, X_test, y_test)
plt.plot([0, 1], [0, 1],
         label='baseline', linestyle='--')
plt.legend();
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\utils\deprecation.py:87: FutureWarning: Function plot_roc_curve is
deprecated; Function :func:`plot_roc_curve` is deprecated in 1.0 and will
be removed in 1.2. Use one of the class methods: :meth:`sklearn.metrics.Ro
cCurveDisplay.from_predictions` or :meth:`sklearn.metrics.RocCurveDisplay.
from_estimator`.
  warnings.warn(msg, category=FutureWarning)
```



The area under the ROC curve measures the degree of overlap between the Specificity and Sensitivity distributions. Greater the area, the less overlap.

Logistic Regression with TIFD Vectorizer

In [168]:

```
pipe_tfid_logreg = Pipeline([('tfid', TfidfVectorizer()),
                 ('lr', LogisticRegression(solver='lbfgs'))
                ])
```

In [169]:

```
cross_val_score(pipe_tfid_logreg, X_train, y_train, cv=5)
```

Out[169]:

```
array([0.7589942 , 0.74003868, 0.74042553, 0.73965184, 0.75812693])
```

In [170]:

```
# ii. Fit into model
pipe_tfid_logreg.fit(X_train, y_train)

# Training score
print(pipe_tfid_logreg.score(X_train, y_train))

# Test score
print(pipe_tfid_logreg.score(X_test, y_test))
```

```
0.8469514082327453
0.75416273955388
```

Gridsearch

In [171]:

```
pipe2_params = {
    'tfid__max_features': [2500, 3000, 3500],
    'tfid__min_df': [1, 2],
    'tfid__max_df': [.8,.9, .95],
    'tfid__ngram_range': [(1,1), (1,2)]
}


gs_tfid_logreg = GridSearchCV(pipe_tfid_logreg,param_grid=pipe2_params,scoring=scorers,r
```

In [172]:

```
gs_tfid_logreg.fit(X_train, y_train)
print(gs_tfid_logreg.best_score_)
gs_tfid_logreg.best_params_
```

```
0.7381625955889839
```

Out[172]:

```
{'tfid__max_df': 0.8,
 'tfid__max_features': 3500,
 'tfid__min_df': 2,
 'tfid__ngram_range': (1, 1)}
```

In [173]:

```
gs_tfid_logreg.score(X_train, y_train)
```

Out[173]:

```
0.8067161869390281
```

In [174]:

```
gs_tfid_logreg.score(X_test, y_test)
```

Out[174]:

```
0.7453660069117185
```

BOOLEAN MASKING ON DATAFRAME

WITH ACTUAL TEST TARGET AND PREDICTED VALUES TO FIND OUT THE FALSE POSITIVES AND FALSE NEGATIVES

In [175]:

```
preds = gs_tfid_logreg.predict(X_test)
```

In [176]:

```
preds = pd.Series(preds)

print(type(preds))
preds
```

```
<class 'pandas.core.series.Series'>
```

Out[176]:

```
0       0
1       0
2       0
3       1
4       1
       ..
6361    1
6362    0
6363    1
6364    0
6365    1
Length: 6366, dtype: int64
```

In [177]:

```
df = pd.concat([X_test, y_test], axis=1).reset_index()
df
```

Out[177]:

	index	Text	subreddit
0	8406	traditional roth tax bracket actually lower	0
1	14781	daily general discussion advice thread july	0
2	7471	hi wondering would good place put pitch invest...	0
3	25723	bed bath amp beyond inc bbby one heavily short...	1
4	20041	go well morning coffee	1
...	...	...	...
6361	13748	drought hitting ca italy france hard	0
6362	21637	needed become hedge fund manager analyst	1
6363	20291	u gdp accelerated pace q better expected growt...	1
6364	14025	rate portfolio individual stocks	0
6365	22170	fake tweet temporarily wiped us billion stock ...	1

6366 rows × 3 columns

In [178]:

```
df = pd.concat([df, preds], axis=1).reset_index()
df.drop(['level_0','index'],axis=1, inplace=True)
df
```

Out[178]:

	Text	subreddit	0
0	traditional roth tax bracket actually lower	0	0
1	daily general discussion advice thread july	0	0
2	hi wondering would good place put pitch invest...	0	0
3	bed bath amp beyond inc bbby one heavily short...	1	1
4	go well morning coffee	1	1
...	...	...	...
6361	drought hitting ca italy france hard	0	1
6362	needed become hedge fund manager analyst	1	0
6363	u gdp accelerated pace q better expected growt...	1	1
6364	rate portfolio individual stocks	0	0
6365	fake tweet temporarily wiped us billion stock ...	1	1

6366 rows × 3 columns

In [179]:

```
false_positive_mask = (df['subreddit']== 0)&(df[0]== 1)
false_negative_mask = (df['subreddit']== 1)&(df[0]== 0)
```

False Positives List

In [180]:

```
df[false_positive_mask]['Text']
```

Out[180]:

```
10      amazon demand problem amazon currently run sal...
76          asana inc nyse asan analyst ideas weekly pick
90                    make sure conviction sentiment true
92                                 much make penny stocks
98      us inflation poised hit four decade high boost...
                              ...
6334                       market catalysts coming month
6339    https youtu uduzfqialgm treacherous waters goi...
6348                        irish whiskey bottles casks
6360                             going gsk glaxo adr us
6361                 drought hitting ca italy france hard
Name: Text, Length: 790, dtype: object
```

False Negatives List

In [181]:

```
df[false_negative_mask]['Text']
```

Out[181]:

```
22      two americans sent prison stealing crypto sim ...
26                              general advice suggestion
33      people think developer sweat economy project m...
34      without wasting time let tell learn ebook lear...
40                     passive income top ways make fast
                              ...
6311             k gt k two months macro forward thinking
6340    serious q experienced probability success clos...
6351                       roast picks please tell wrong
6353    letting financially literate folks test skills...
6362             needed become hedge fund manager analyst
Name: Text, Length: 831, dtype: object
```

Accuracy Check [Logistic Regression with TFID Vectorizer]

Pipeline Accuracy

In [182]:

```
# Get predictions
preds = pipe_tfid_logreg.predict(X_test)

# Save confusion matrix values
tn, fp, fn, tp = confusion_matrix(y_test, preds).ravel()
```

In [183]:

```
confusion_matrix(y_test, preds)
```

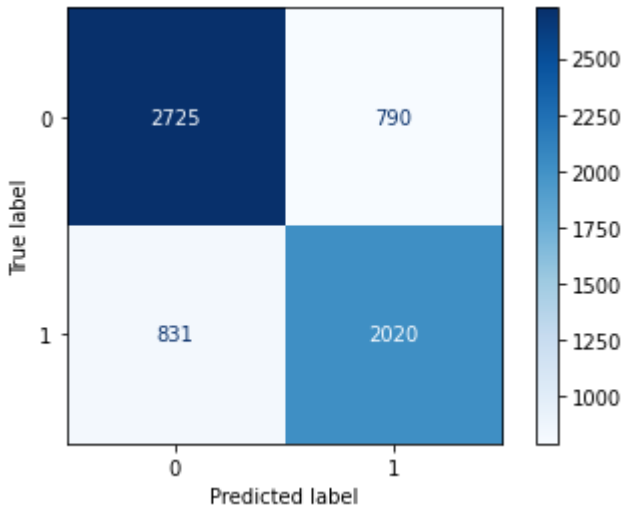
Out[183]:

```
array([[2742,  773],
       [ 792, 2059]], dtype=int64)
```

In [184]:

```
plot_confusion_matrix(gs_tfid_logreg, X_test, y_test, cmap='Blues', values_format='d');
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\utils\deprecation.py:87: FutureWarning: Function plot_confusion_mat
rix is deprecated; Function `plot_confusion_matrix` is deprecated in 1.0 a
nd will be removed in 1.2. Use one of the class methods: ConfusionMatrixDi
splay.from_predictions or ConfusionMatrixDisplay.from_estimator.
  warnings.warn(msg, category=FutureWarning)
```



In [185]:

```
# Calculate the specificity

spec = tn / (tn + fp)

print('Specificity:', spec)
```

```
Specificity: 0.7800853485064011
```

In [186]:

```
# Calculate the sensitivity

sens = tp/(tp+fn)

print('Sensitivity:', sens)
```

```
Sensitivity: 0.7222027358821466
```

In [187]:

```
accuracy = (tp+tn)/(tp+fp+tn+fn)

print('Accuracy:', accuracy)
```

```
Accuracy: 0.75416273955388
```

Gridsearch Accuracy

In [188]:

```
# Get predictions
preds = gs_tfid_logreg.predict(X_test)

# Save confusion matrix values
tn, fp, fn, tp = confusion_matrix(y_test, preds).ravel()
```

In [189]:

```
cm2 = confusion_matrix(y_test, preds)
cm2
```

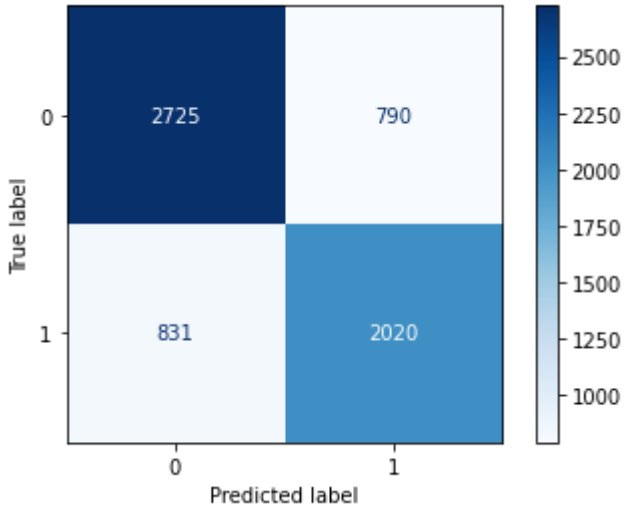
Out[189]:

```
array([[2725,  790],
       [ 831, 2020]], dtype=int64)
```

In [190]:

```
plot_confusion_matrix(gs_tfid_logreg, X_test, y_test, cmap='Blues', values_format='d');
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\utils\deprecation.py:87: FutureWarning: Function plot_confusion_mat
rix is deprecated; Function `plot_confusion_matrix` is deprecated in 1.0 a
nd will be removed in 1.2. Use one of the class methods: ConfusionMatrixDi
splay.from_predictions or ConfusionMatrixDisplay.from_estimator.
  warnings.warn(msg, category=FutureWarning)
```



Error Analysis [Type 1 and Type 2 Errors]

https://www.datasciencecentral.com/understanding-type-i-and-type-ii-errors/ (https://www.datasciencecentral.com/understanding-type-i-and-type-ii-errors/)

How many Type I errors [FALSE POSITIVE] are there?

In [191]:

```
fp
```

Out[191]:

```
790
```

How many Type II errors [FALSE NEGATIVE] are there?

In [192]:

```
fn
```

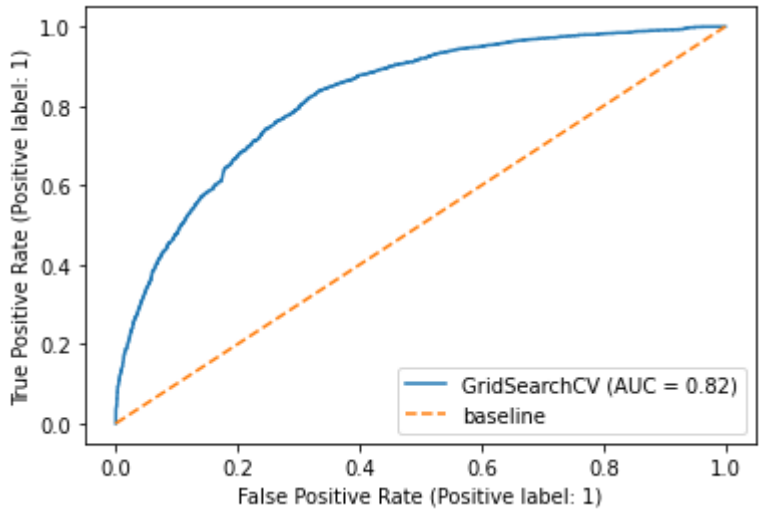
Out[192]:

```
831
```

In [193]:

```
plot_roc_curve(gs_tfid_logreg, X_test, y_test)
plt.plot([0, 1], [0, 1],
         label='baseline', linestyle='--')
plt.legend();
```

```
c:\Users\redoc\AppData\Local\Programs\Python\Python310\lib\site-packages\s
klearn\utils\deprecation.py:87: FutureWarning: Function plot_roc_curve is
deprecated; Function :func:`plot_roc_curve` is deprecated in 1.0 and will
be removed in 1.2. Use one of the class methods: :meth:`sklearn.metrics.Ro
cCurveDisplay.from_predictions` or :meth:`sklearn.metrics.RocCurveDisplay.
from_estimator`.
  warnings.warn(msg, category=FutureWarning)
```



The area under the ROC curve measures the degree of overlap between the Specificity and Sensitivity distributions. Greater the area, the less overlap.