In [103…

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import LabelEncoder
from nltk import corpus
from nltk.corpus import stopwords
#this is for punctuation
import string
import nltk
from nltk.stem.porter import PorterStemmer
from wordcloud import WordCloud
from collections import Counter
from sklearn.feature_extraction.text import CountVectorizer,TfidfVectorizer
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB,MultinomialNB,BernoulliNB
from sklearn.metrics import accuracy_score,confusion_matrix,precision_score
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier,AdaBoostClassifier,BaggingClassifier,E
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from xgboost import XGBClassifier
from sklearn.preprocessing import MinMaxScaler
from sklearn.ensemble import VotingClassifier
import pickle
```

In [2]:

```
df = pd.read_csv('/Users/mac/Desktop/DataScience/NLP/Spam-Ham-Classifier/spam.csv',encodir
```

In [3]:

```
df.head()
```

Out[3]:

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
0	ham	Go until jurong point, crazy.. Available only ...	NaN	NaN	NaN
1	ham	Ok lar... Joking wif u oni...	NaN	NaN	NaN
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...	NaN	NaN	NaN
3	ham	U dun say so early hor... U c already then say...	NaN	NaN	NaN
4	ham	Nah I don't think he goes to usf, he lives aro...	NaN	NaN	NaN

In [4]:

```
df.shape
```

Out[4]:

```
(5572, 5)
```

- There are 5572 sms

1. Data Cleaning

In [5]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5572 entries, 0 to 5571
```

```
Data columns (total 5 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   v1          5572 non-null   object
 1   v2          5572 non-null   object
 2   Unnamed: 2  50 non-null     object
 3   Unnamed: 3  12 non-null     object
 4   Unnamed: 4  6 non-null      object
dtypes: object(5)
memory usage: 217.8+ KB
```

In [6]:
```
#dropping the columns
df.drop(['Unnamed: 2','Unnamed: 3','Unnamed: 4'],axis=1,inplace=True)
```

In [7]:
```
df.sample(5)
```

Out[7]:

	v1	v2
2802	spam	FreeMsg>FAV XMAS TONES!Reply REAL
2858	ham	Do you know why god created gap between your f...
163	spam	-PLS STOP bootydelious (32/F) is inviting you ...
1022	ham	We still on for tonight?
3174	spam	UR GOING 2 BAHAMAS! CallFREEFONE 08081560665 a...

In [8]:
```
df.rename(columns={'v1':'Target','v2':'Text'},inplace=True)
```

In [9]:
```
df.head()
```

Out[9]:

	Target	Text
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...

In [10]:
```
encoder = LabelEncoder()
df['Target'] = encoder.fit_transform(df['Target'])
```

In [11]:
```
df.head()
```

Out[11]:

	Target	Text
0	0	Go until jurong point, crazy.. Available only ...
1	0	Ok lar... Joking wif u oni...
2	1	Free entry in 2 a wkly comp to win FA Cup fina...
3	0	U dun say so early hor... U c already then say...
4	0	Nah I don't think he goes to usf, he lives aro...

In [12]:
```
#checking missing values
df.isnull().sum()
```

Out[12]:
```
Target    0
Text      0
dtype: int64
```

In [13]:
```
#checking for duplicates
df.duplicated().sum()
```

Out[13]:
```
403
```

In [14]:
```
df = df.drop_duplicates(keep='first')
```

In [15]:
```
df.shape
```

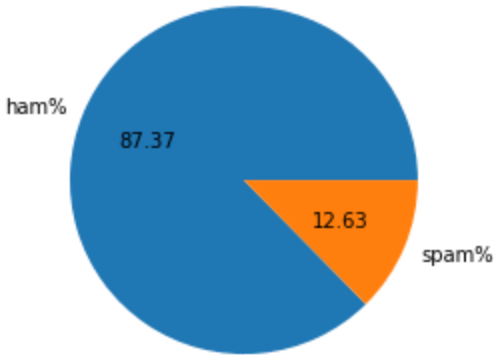
Out[15]:
```
(5169, 2)
```

2. EDA

In [16]:
```
(df['Target'].value_counts()/df.shape[0])*100
```

Out[16]:
```
0    87.366996
1    12.633004
Name: Target, dtype: float64
```

In [17]:
```
plt.pie((df['Target'].value_counts()/df.shape[0])*100,labels=['ham%','spam%'],autopct='%0.
plt.show()
```



- Clearly this is a case of imbalanced data.

In [18]:
```
#nltk.download('punkt')
```

In [19]:
```
#numer of char in each sentence
df['Num_Chars'] = df['Text'].apply(len)
```

In [20]:
```
#fetch the number of words
```

```
df['Num_Words'] = df['Text'].apply(lambda x: len(nltk.word_tokenize(x)))
```

In [21]:
```
#number of sentences
df['Num_Sentences'] = df['Text'].apply(lambda x:len(nltk.sent_tokenize(x)))
```

In [22]:
```
df.head(3)
```

Out[22]:

	Target	Text	Num_Chars	Num_Words	Num_Sentences
0	0	Go until jurong point, crazy.. Available only ...	111	24	2
1	0	Ok lar... Joking wif u oni...	29	8	2
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2

In [23]:
```
df.describe()
```

Out[23]:

	Target	Num_Chars	Num_Words	Num_Sentences
count	5169.000000	5169.000000	5169.000000	5169.000000
mean	0.126330	78.977945	18.455407	1.961308
std	0.332253	58.236293	13.322448	1.432583
min	0.000000	2.000000	1.000000	1.000000
25%	0.000000	36.000000	9.000000	1.000000
50%	0.000000	60.000000	15.000000	1.000000
75%	0.000000	117.000000	26.000000	2.000000
max	1.000000	910.000000	220.000000	38.000000

In [24]:
```
ham = df[df['Target'] == 0]
ham.describe()
```

Out[24]:

	Target	Num_Chars	Num_Words	Num_Sentences
count	4516.0	4516.000000	4516.000000	4516.000000
mean	0.0	70.459256	17.123339	1.815545
std	0.0	56.358207	13.491315	1.364098
min	0.0	2.000000	1.000000	1.000000
25%	0.0	34.000000	8.000000	1.000000
50%	0.0	52.000000	13.000000	1.000000
75%	0.0	90.000000	22.000000	2.000000
max	0.0	910.000000	220.000000	38.000000

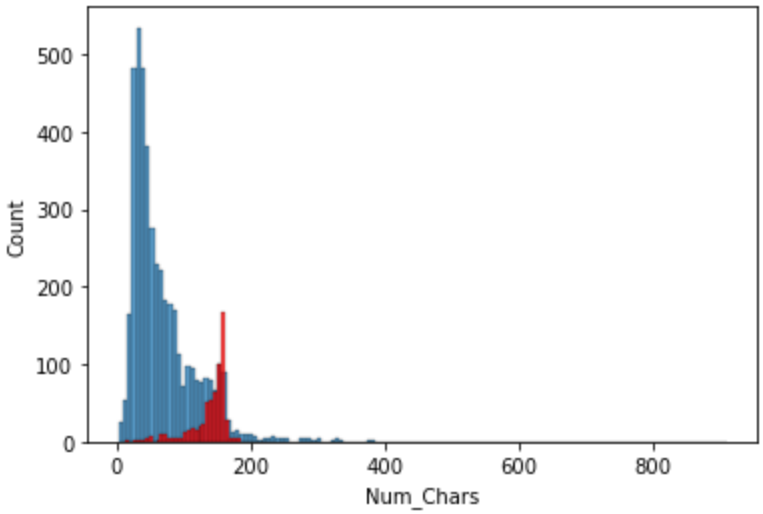
In [25]:
```
spam = df[df['Target'] == 1]
spam.describe()
```

Out[25]:

	Target	Num_Chars	Num_Words	Num_Sentences
count	653.0	653.000000	653.000000	653.000000

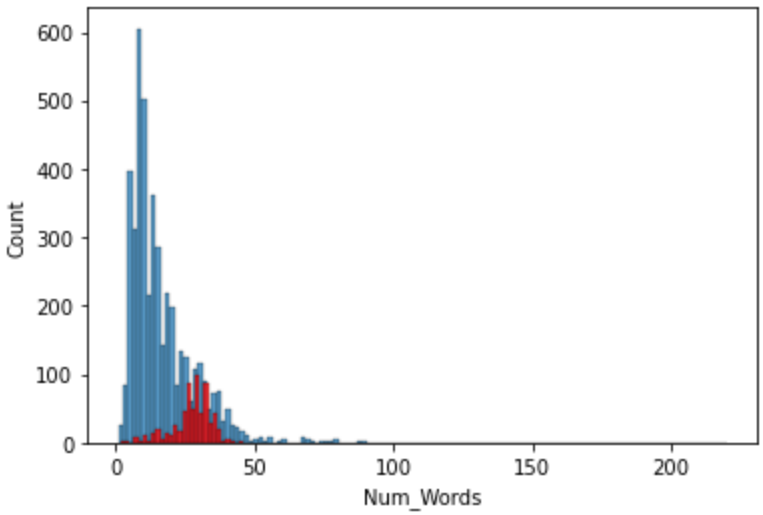
	Target	Num_Chars	Num_Words	Num_Sentences
mean	1.0	137.891271	27.667688	2.969372
std	0.0	30.137753	7.008418	1.488910
min	1.0	13.000000	2.000000	1.000000
25%	1.0	132.000000	25.000000	2.000000
50%	1.0	149.000000	29.000000	3.000000
75%	1.0	157.000000	32.000000	4.000000
max	1.0	224.000000	46.000000	9.000000

In [26]:
```
sns.histplot(ham['Num_Chars'])
sns.histplot(spam['Num_Chars'],color='red');
```

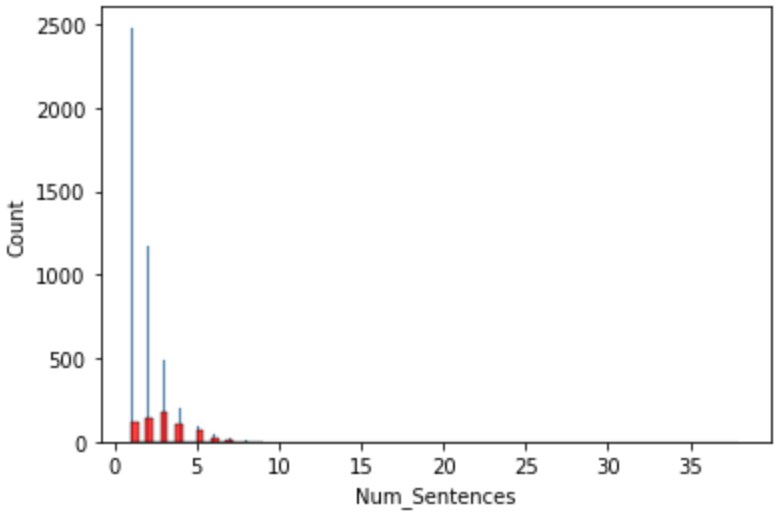


- We can see through this graph that spam messages uses more character than ham

In [27]:
```
sns.histplot(ham['Num_Words'])
sns.histplot(spam['Num_Words'],color='red');
```

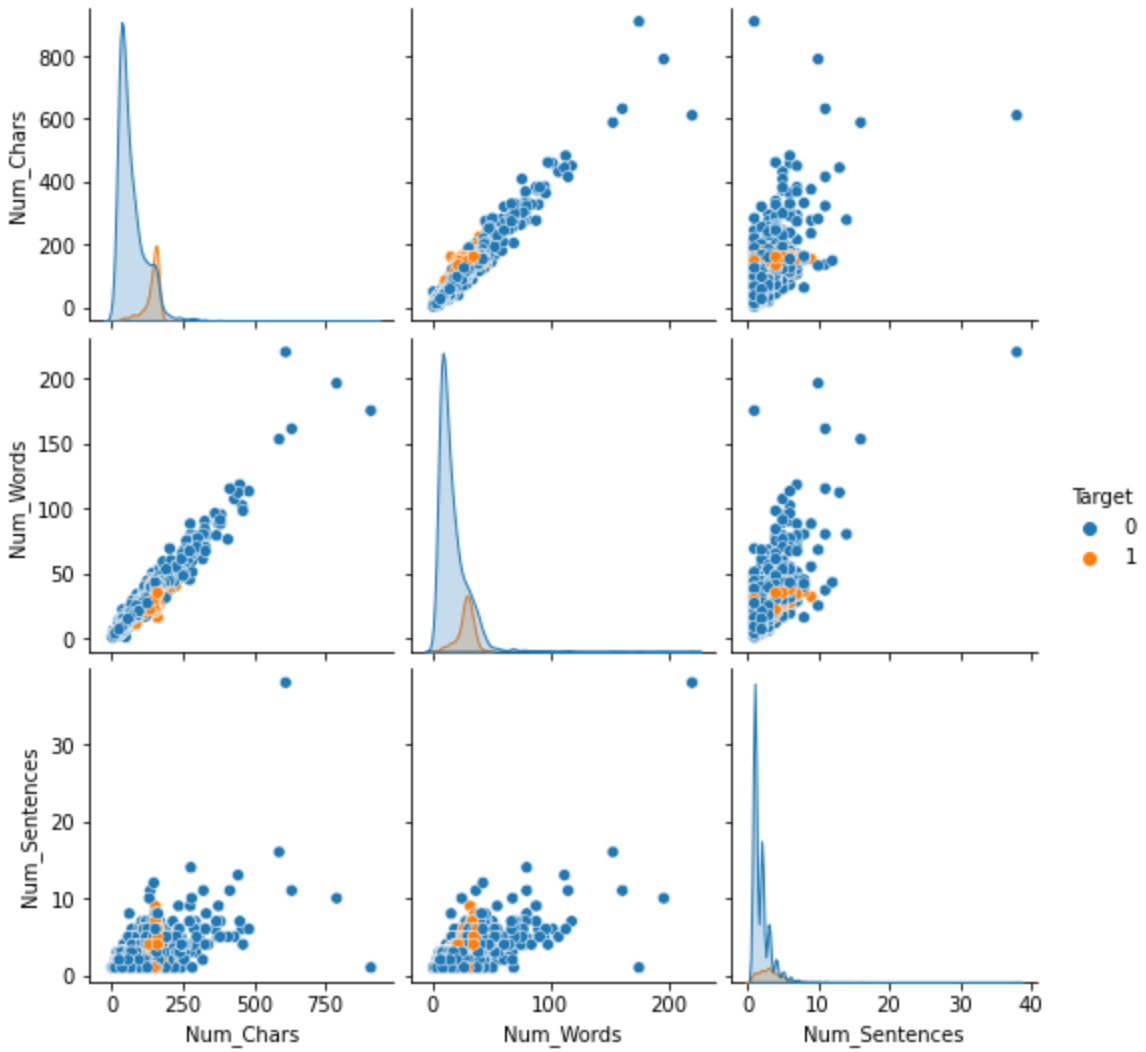


In [28]:
```
sns.histplot(ham['Num_Sentences'])
sns.histplot(spam['Num_Sentences'],color='red');
```



In [29]:

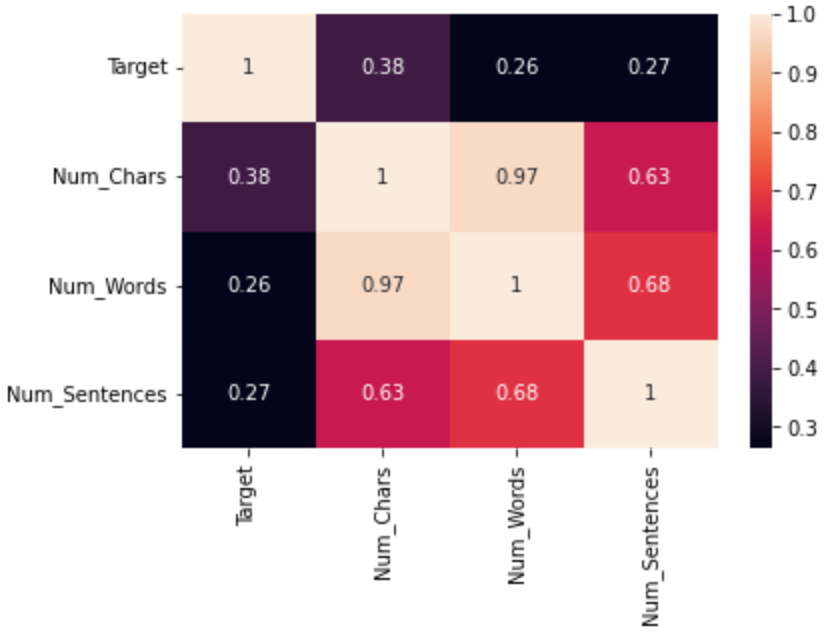
```
sns.pairplot(hue='Target',data=df);
```



- There are outliers.

In [30]:

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



- Since there is high multi collinearity between feature. Therefore while building model we will only take one of the festures.

In [31]:
```
def transform_text(text):
    text = text.lower()
    text = nltk.word_tokenize(text)
    #removing special chars
    y = []
    for i in text:
        if i.isalnum():
            y.append(i)

    text = y[:] #clonning of list
    y.clear()
    for i in text:
        if i not in stopwords.words('english') and i not in string.punctuation:
            y.append(i)

    text = y[:] #clonning of list
    y.clear()

    ps = PorterStemmer()

    for i in text:
        y.append(ps.stem(i))


    return ' '.join(y)
```

In [32]:
```
transform_text('how are you Annie 3456778 %$^ ?')
```

Out[32]:
```
'anni 3456778'
```

In [33]:
```
df['Transformed_Text'] = df['Text'].apply(transform_text)
```

In [34]:
```
df.head()
```

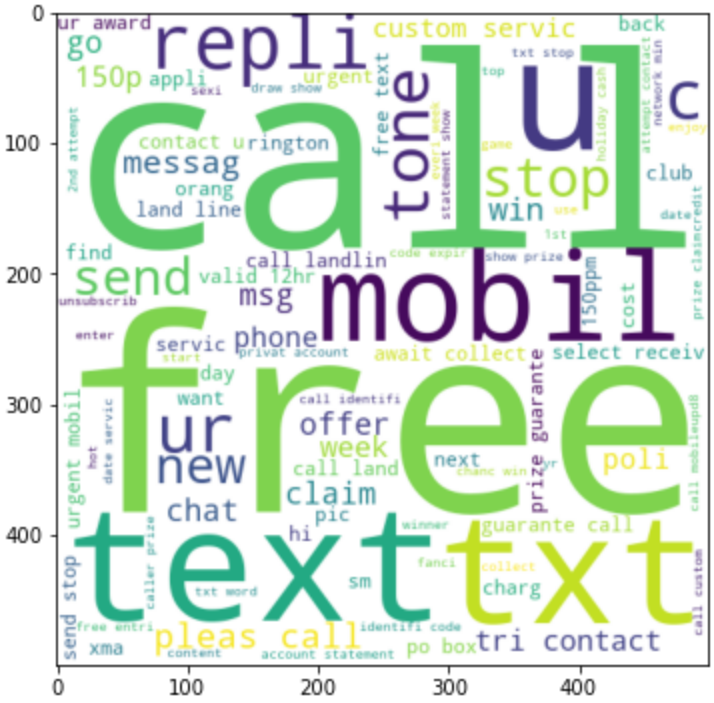
Out[34]:

	Target	Text	Num_Chars	Num_Words	Num_Sentences	Transformed_Text
0	0	Go until jurong point, crazy.. Available only ...	111	24	2	go jurong point crazi avail bugi n great world...
1	0	Ok lar... Joking wif u oni...	29	8	2	ok lar joke wif u oni
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2	free entri 2 wkli comp win fa cup final tkt 21...
3	0	U dun say so early hor... U c already then say...	49	13	1	u dun say earli hor u c alreadi say
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1	nah think goe usf live around though

In [35]:
```
wc = WordCloud(width=500,height=500,min_font_size=10,background_color='white')
```

In [36]:
```
spam_wc = wc.generate(df[df['Target']==1]['Transformed_Text'].str.cat(sep=' '))
plt.figure(figsize=(15,6))
plt.imshow(spam_wc)
```

Out[36]:
```
<matplotlib.image.AxesImage at 0x7fa3f9401bb0>
```



In [37]:
```
ham_wc = wc.generate(df[df['Target']==0]['Transformed_Text'].str.cat(sep=' '))
plt.figure(figsize=(15,6))
plt.imshow(ham_wc)
```

Out[37]:
```
<matplotlib.image.AxesImage at 0x7fa3f8de16d0>
```

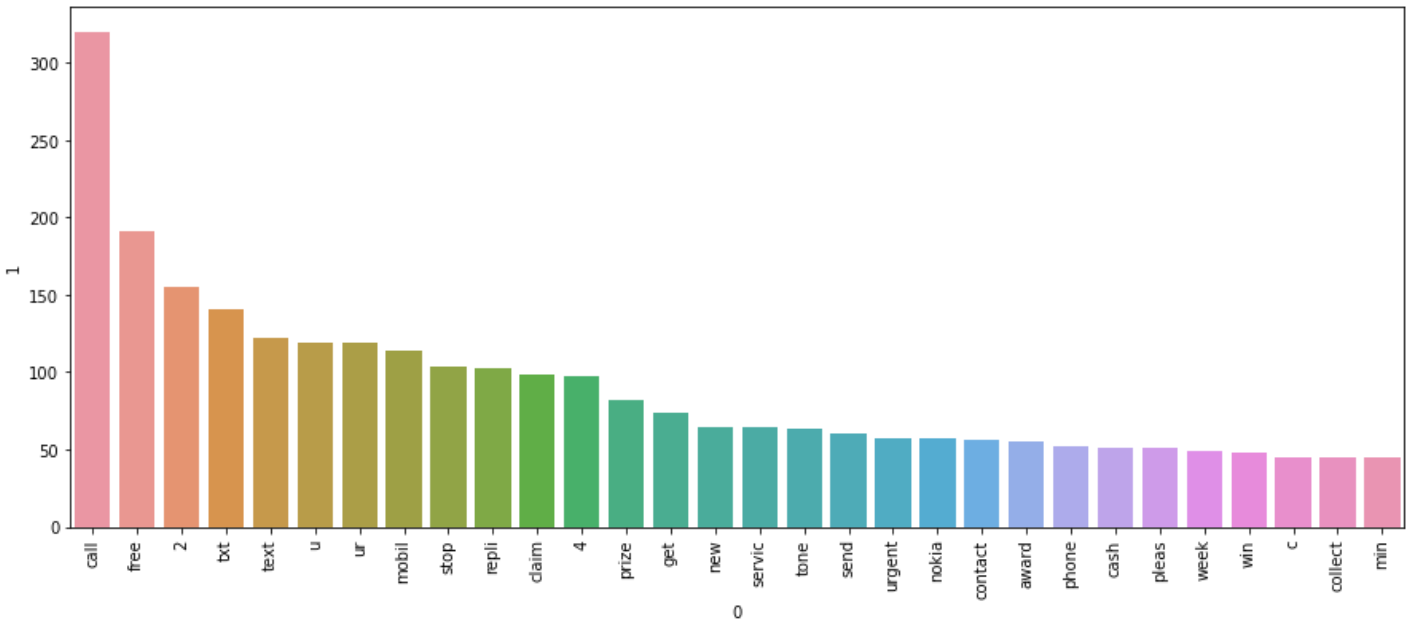
In [38]:

```
spam_corpus = []
for msg in df[df['Target']==1]['Transformed_Text'].tolist():
    for word in msg.split():
        spam_corpus.append(word)
```

In [39]:

```
sp=pd.DataFrame(Counter(spam_corpus).most_common(30))
plt.figure(figsize=(15,6))
sns.barplot(sp[0],sp[1])
plt.xticks(rotation='vertical')
plt.show()
```

```
/Users/mac/opt/anaconda3/lib/python3.8/site-packages/seaborn/_decorators.py:36: FutureWarn
ing: Pass the following variables as keyword args: x, y. From version 0.12, the only valid
positional argument will be `data`, and passing other arguments without an explicit keywor
d will result in an error or misinterpretation.
  warnings.warn(
```



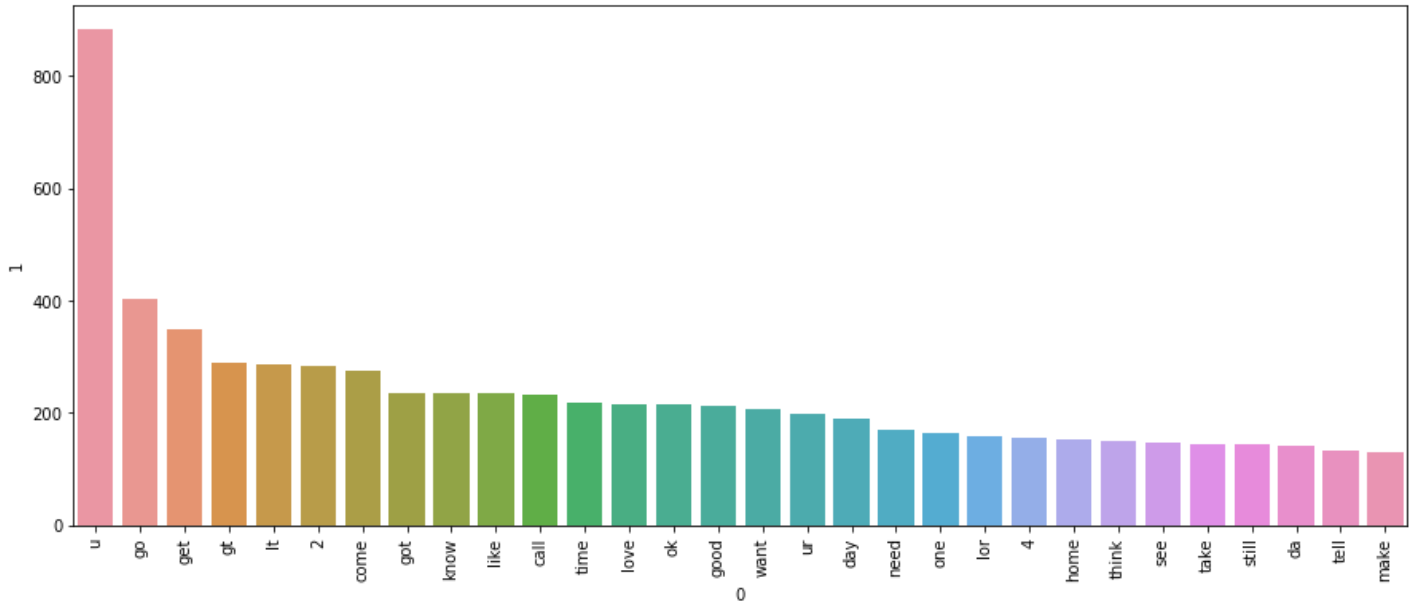
In [40]:

```
ham_corpus = []
for msg in df[df['Target']==0]['Transformed_Text'].tolist():
```

```
    for word in msg.split():
        ham_corpus.append(word)
```

In [41]:
```
h=pd.DataFrame(Counter(ham_corpus).most_common(30))
plt.figure(figsize=(15,6))
sns.barplot(h[0],h[1])
plt.xticks(rotation='vertical')
plt.show()
```

```
/Users/mac/opt/anaconda3/lib/python3.8/site-packages/seaborn/_decorators.py:36: FutureWarn
ing: Pass the following variables as keyword args: x, y. From version 0.12, the only valid
positional argument will be `data`, and passing other arguments without an explicit keywor
d will result in an error or misinterpretation.
  warnings.warn(
```



Model Building

In [42]:
```
cv = CountVectorizer()
X = cv.fit_transform(df['Transformed_Text']).toarray()
```

In [43]:
```
X.shape
```

Out[43]:
```
(5169, 6708)
```

In [44]:
```
y = df['Target'].values
```

In [45]:
```
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.2,random_state=2)
```

In [46]:
```
gng = GaussianNB()
bnb = BernoulliNB()
mnb = MultinomialNB()
```

In [47]:
```
gng.fit(X_train,y_train)
y_pred1 = gng.predict(X_test)
print('Accuracy:',accuracy_score(y_test,y_pred1))
```

```
print('Confusion Matrix:',confusion_matrix(y_test,y_pred1))
print('Precision Score:',precision_score(y_test,y_pred1))
```

```
Accuracy: 0.8800773694390716
Confusion Matrix: [[792 104]
 [ 20 118]]
Precision Score: 0.5315315315315315
```

In [48]:

```
mnb.fit(X_train,y_train)
y_pred2 = mnb.predict(X_test)
print('Accuracy:',accuracy_score(y_test,y_pred2))
print('Confusion Matrix:',confusion_matrix(y_test,y_pred2))
print('Precision Score:',precision_score(y_test,y_pred2))
```

```
Accuracy: 0.9642166344294004
Confusion Matrix: [[871  25]
 [ 12 126]]
Precision Score: 0.8344370860927153
```

In [49]:

```
bnb.fit(X_train,y_train)
y_pred3 = bnb.predict(X_test)
print('Accuracy:',accuracy_score(y_test,y_pred3))
print('Confusion Matrix:',confusion_matrix(y_test,y_pred3))
print('Precision Score:',precision_score(y_test,y_pred3))
```

```
Accuracy: 0.9700193423597679
Confusion Matrix: [[893   3]
 [ 28 110]]
Precision Score: 0.9734513274336283
```

- Since there is an imbalanced data hence precision matters here most.

Using tf-idf

In [104…

```
tv = TfidfVectorizer()
X = tv.fit_transform(df['Transformed_Text']).toarray()
```

In [105…

```
y = df['Target'].values
```

In [106…

```
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.2,random_state=2)
```

In [107…

```
gnb = GaussianNB()
bnb = BernoulliNB()
mnb = MultinomialNB()
```

In [108…

```
gnb.fit(X_train,y_train)
y_pred1 = gnb.predict(X_test)
print('Accuracy:',accuracy_score(y_test,y_pred1))
print('Confusion Matrix:',confusion_matrix(y_test,y_pred1))
print('Precision Score:',precision_score(y_test,y_pred1))
```

```
Accuracy: 0.8762088974854932
Confusion Matrix: [[793 103]
 [ 25 113]]
Precision Score: 0.5231481481481481
```

In [109…

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

```
y_pred2 = mnb.predict(X_test)
print('Accuracy:',accuracy_score(y_test,y_pred2))
print('Confusion Matrix:',confusion_matrix(y_test,y_pred2))
print('Precision Score:',precision_score(y_test,y_pred2))
```

```
Accuracy: 0.9593810444874274
Confusion Matrix: [[896   0]
 [ 42  96]]
Precision Score: 1.0
```

In [56]:

```
bnb.fit(X_train,y_train)
y_pred3 = bnb.predict(X_test)
print('Accuracy:',accuracy_score(y_test,y_pred3))
print('Confusion Matrix:',confusion_matrix(y_test,y_pred3))
print('Precision Score:',precision_score(y_test,y_pred3))
```

```
Accuracy: 0.9700193423597679
Confusion Matrix: [[893   3]
 [ 28 110]]
Precision Score: 0.9734513274336283
```

- choosen tf-idf and algo- Multinomial

In [57]:

```
svc = SVC(kernel='sigmoid', gamma=1.0)
knc = KNeighborsClassifier()
mnb = MultinomialNB()
dtc = DecisionTreeClassifier(max_depth=5)
lrc = LogisticRegression(solver='liblinear', penalty='l1')
rfc = RandomForestClassifier(n_estimators=50, random_state=2)
abc = AdaBoostClassifier(n_estimators=50, random_state=2)
bc = BaggingClassifier(n_estimators=50, random_state=2)
etc = ExtraTreesClassifier(n_estimators=50, random_state=2)
gbdt = GradientBoostingClassifier(n_estimators=50,random_state=2)
xgb = XGBClassifier(n_estimators=50,random_state=2)
```

In [58]:

```
clfs = {
    'SVC':svc,
    'KN':knc,
    'NB':mnb,
    'DT': dtc,
    'LR': lrc,
    'RF': rfc,
    'AdaBoost': abc,
    'BgC': bc,
    'ETC': etc,
    'GBDT':gbdt,
    'xgb':xgb
}
```

In [59]:

```
def train_classifier(clf,X_train,y_train,X_test,y_test):
    clf.fit(X_train,y_train)
    y_pred = clf.predict(X_test)
    accuracy = accuracy_score(y_test,y_pred)
    precision = precision_score(y_test,y_pred)

    return accuracy,precision
```

In [60]:

```
train_classifier(svc,X_train,y_train,X_test,y_test)
```

Out[60]: (0.9729206963249516, 0.9741379310344828)

In [61]:
```
accuracy_scores = []
precision_scores = []

for name,clf in clfs.items():

    current_accuracy,current_precision = train_classifier(clf, X_train,y_train,X_test,y_te

    print("For ",name)
    print("Accuracy - ",current_accuracy)
    print("Precision - ",current_precision)

    accuracy_scores.append(current_accuracy)
    precision_scores.append(current_precision)
```

```
For  SVC
Accuracy -  0.9729206963249516
Precision -  0.9741379310344828
For  KN
Accuracy -  0.9003868471953579
Precision -  1.0
For  NB
Accuracy -  0.9593810444874274
Precision -  1.0
For  DT
Accuracy -  0.9361702127659575
Precision -  0.8461538461538461
For  LR
Accuracy -  0.9516441005802708
Precision -  0.94
For  RF
Accuracy -  0.971953578336557
Precision -  1.0
For  AdaBoost
Accuracy -  0.9613152804642167
Precision -  0.9454545454545454
For  BgC
Accuracy -  0.9584139264990329
Precision -  0.8625954198473282
For  ETC
Accuracy -  0.9729206963249516
Precision -  0.9824561403508771
For  GBDT
Accuracy -  0.9526112185686654
Precision -  0.9238095238095239
For  xgb
Accuracy -  0.9700193423597679
Precision -  0.9349593495934959
```

In [62]:
```
performance_df = pd.DataFrame({'Algorithm':clfs.keys(),'Accuracy':accuracy_scores,'Precisi
```

In [63]:
```
performance_df
```

Out[63]:

	Algorithm	Accuracy	Precision
1	KN	0.900387	1.000000
2	NB	0.959381	1.000000
5	RF	0.971954	1.000000
8	ETC	0.972921	0.982456

	Algorithm	Accuracy	Precision
0	SVC	0.972921	0.974138
6	AdaBoost	0.961315	0.945455
4	LR	0.951644	0.940000
10	xgb	0.970019	0.934959
9	GBDT	0.952611	0.923810
7	BgC	0.958414	0.862595
3	DT	0.936170	0.846154

In [64]:
```
performance_df1 = pd.melt(performance_df, id_vars = "Algorithm")
```

In [65]:
```
performance_df1
```

Out[65]:

	Algorithm	variable	value
0	KN	Accuracy	0.900387
1	NB	Accuracy	0.959381
2	RF	Accuracy	0.971954
3	ETC	Accuracy	0.972921
4	SVC	Accuracy	0.972921
5	AdaBoost	Accuracy	0.961315
6	LR	Accuracy	0.951644
7	xgb	Accuracy	0.970019
8	GBDT	Accuracy	0.952611
9	BgC	Accuracy	0.958414
10	DT	Accuracy	0.936170
11	KN	Precision	1.000000
12	NB	Precision	1.000000
13	RF	Precision	1.000000
14	ETC	Precision	0.982456
15	SVC	Precision	0.974138
16	AdaBoost	Precision	0.945455
17	LR	Precision	0.940000
18	xgb	Precision	0.934959
19	GBDT	Precision	0.923810
20	BgC	Precision	0.862595
21	DT	Precision	0.846154

In [66]:
```
# model improve
# 1. Change the max_features parameter of TfIdf
```

In [67]:
```
tv = TfidfVectorizer(max_features=3000)
X = tv.fit_transform(df['Transformed_Text']).toarray()
y = df['Target'].values
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.2,random_state=2)
```

In [68]:
```
svc = SVC(kernel='sigmoid', gamma=1.0)
knc = KNeighborsClassifier()
mnb = MultinomialNB()
dtc = DecisionTreeClassifier(max_depth=5)
lrc = LogisticRegression(solver='liblinear', penalty='l1')
rfc = RandomForestClassifier(n_estimators=50, random_state=2)
abc = AdaBoostClassifier(n_estimators=50, random_state=2)
bc = BaggingClassifier(n_estimators=50, random_state=2)
etc = ExtraTreesClassifier(n_estimators=50, random_state=2)
gbdt = GradientBoostingClassifier(n_estimators=50,random_state=2)
xgb = XGBClassifier(n_estimators=50,random_state=2)
```

In [69]:
```
clfs = {
    'SVC':svc,
    'KN':knc,
    'NB':mnb,
    'DT': dtc,
    'LR': lrc,
    'RF': rfc,
    'AdaBoost': abc,
    'BgC': bc,
    'ETC': etc,
    'GBDT':gbdt,
    'xgb':xgb
}
```

In [70]:
```
def train_classifier(clf,X_train,y_train,X_test,y_test):
    clf.fit(X_train,y_train)
    y_pred = clf.predict(X_test)
    accuracy = accuracy_score(y_test,y_pred)
    precision = precision_score(y_test,y_pred)

    return accuracy,precision
```

In [71]:
```
accuracy_scores = []
precision_scores = []

for name,clf in clfs.items():

    current_accuracy,current_precision = train_classifier(clf, X_train,y_train,X_test,y_te

    print("For ",name)
    print("Accuracy - ",current_accuracy)
    print("Precision - ",current_precision)

    accuracy_scores.append(current_accuracy)
    precision_scores.append(current_precision)
```

```
For  SVC
Accuracy -  0.9758220502901354
Precision -  0.9747899159663865
For  KN
Accuracy -  0.9052224371373307
Precision -  1.0
For  NB
```

```
Accuracy -  0.9709864603481625
Precision -  1.0
For  DT
Accuracy -  0.9303675048355899
Precision -  0.8367346938775511
For  LR
Accuracy -  0.9584139264990329
Precision -  0.9702970297029703
For  RF
Accuracy -  0.9758220502901354
Precision -  0.9829059829059829
For  AdaBoost
Accuracy -  0.960348162475822
Precision -  0.9292035398230089
For  BgC
Accuracy -  0.9584139264990329
Precision -  0.8682170542635659
For  ETC
Accuracy -  0.9748549323017408
Precision -  0.9745762711864406
For  GBDT
Accuracy -  0.9468085106382979
Precision -  0.9191919191919192
For  xgb
Accuracy -  0.9671179883945842
Precision -  0.9333333333333333
```

In [74]:
```
performance_df1 = pd.DataFrame({'Algorithm':clfs.keys(),'Accuracy_max_ft3000':accuracy_sc
```

In [75]:
```
performance_df1
```

Out[75]:

	Algorithm	Accuracy_max_ft3000	Precision_max_ft3000
1	KN	0.905222	1.000000
2	NB	0.970986	1.000000
5	RF	0.975822	0.982906
0	SVC	0.975822	0.974790
8	ETC	0.974855	0.974576
4	LR	0.958414	0.970297
10	xgb	0.967118	0.933333
6	AdaBoost	0.960348	0.929204
9	GBDT	0.946809	0.919192
7	BgC	0.958414	0.868217
3	DT	0.930368	0.836735

In [83]:
```
performance_df = pd.merge(on='Algorithm',left=performance_df,right=performance_df1)
```

In [84]:
```
performance_df
```

Out[84]:

	Algorithm	Accuracy	Precision	Accuracy_max_ft3000	Precision_max_ft3000
0	KN	0.900387	1.000000	0.905222	1.000000

	Algorithm	Accuracy	Precision	Accuracy_max_ft3000	Precision_max_ft3000
1	NB	0.959381	1.000000	0.970986	1.000000
2	RF	0.971954	1.000000	0.975822	0.982906
3	ETC	0.972921	0.982456	0.974855	0.974576
4	SVC	0.972921	0.974138	0.975822	0.974790
5	AdaBoost	0.961315	0.945455	0.960348	0.929204
6	LR	0.951644	0.940000	0.958414	0.970297
7	xgb	0.970019	0.934959	0.967118	0.933333
8	GBDT	0.952611	0.923810	0.946809	0.919192
9	BgC	0.958414	0.862595	0.958414	0.868217
10	DT	0.936170	0.846154	0.930368	0.836735

- The benefit we got is that our accuracy increased in somecases. #### Voting Classifier

In [100…
```
#taking the models that performed nicely
rfc = RandomForestClassifier(n_estimators=50, random_state=2)
etc = ExtraTreesClassifier(n_estimators=50, random_state=2)
svc = SVC(kernel='sigmoid', gamma=1.0,probability=True)
mnb = MultinomialNB()

vc = VotingClassifier(estimators = [('svm',svc),('rfc',rfc),('etc',etc),('mnb',mnb)],votir
```

In [101…
```
vc.fit(X_train,y_train)
```

Out[101…
```
VotingClassifier(estimators=[('svm',
                              SVC(gamma=1.0, kernel='sigmoid',
                                  probability=True)),
                             ('rfc',
                              RandomForestClassifier(n_estimators=50,
                                                     random_state=2)),
                             ('etc',
                              ExtraTreesClassifier(n_estimators=50,
                                                   random_state=2)),
                             ('mnb', MultinomialNB())],
                 voting='soft')
```

In [102…
```
y_pred = vc.predict(X_test)
print('Accuracy:',accuracy_score(y_test,y_pred))
print('Precision Score:',precision_score(y_test,y_pred))
```

```
Accuracy: 0.9796905222437138
Precision Score: 0.9915966386554622
```

- We are gonna apply Naive Bayes

In [111…
```
pickle.dump(tv,open('vectorizer.pkl','wb'))
pickle.dump(mnb,open('sms_model.pkl','wb'))
```

In [ ]:
```
```

In [ ]:

In [ ]:

In [ ]: