In [1]:

```
import pandas as pd
pd.set_option('display.max_rows', 1000)

import numpy as np
from numpy import mean

import matplotlib.pyplot as plt

#turn off warnings for final run
import warnings
warnings.filterwarnings('ignore')
```

In [2]:

```
from sklearn import metrics
from sklearn.preprocessing import StandardScaler

from sklearn.model_selection import train_test_split
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import StratifiedKFold
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV

from sklearn.feature_selection import RFE
from sklearn.feature_selection import RFECV

from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import RandomForestClassifier


from statsmodels.stats.outliers_influence import variance_inflation_factor
```

Data Load and Preparation

In [3]:

```
#import sales csv
calls = pd.read_csv('cleaned_calls.csv')
```

In [4]:

```
#ceate column to indicate if call ended in sale based on customer existance
calls['sale'] = 0
calls.loc[calls['Zip'].notnull(), ['sale']] = 1
```

In [5]:

```
#only include a subset of the variables
```

```
calls_subset = calls[['Duration', 'Start Time', 'Keywords', 'Campaign', 'Page',
                      'Device Type', 'Browser', 'Referrer', 'sale', 'State']]
calls_subset
```

Out[5]:

	Duration	Start Time	Keywords	Campaign	Page	Device Type	Browser	Referrer	sale	State
0	167	12/22/2021 12:45	NaN	NaN	main/estate-planning-ppc/	mobile	Chrome	www.google.com	0	PA
1	115	12/22/2021 12:36	NaN	Medicaid - Elder Law - 001	NaN	NaN	NaN	NaN	0	IA
2	106	12/22/2021 12:23	NaN	NaN	main/	desktop	Chrome	direct	0	PA
3	33	12/22/2021 12:01	NaN	NaN	NaN	NaN	NaN	NaN	0	PA
4	112	12/22/2021 11:47	NaN	NaN	NaN	NaN	NaN	NaN	0	CA
...	...	...	...	...	...	...	...	...	...	...
1780	18	1/5/2021 8:47	NaN	NaN	NaN	NaN	NaN	NaN	0	PA
1781	44	1/5/2021 8:23	power of attorney will	Estate Planning 005	main/estate-planning-ppc/	desktop	Chrome	www.google.com	0	NY
1782	188	1/4/2021 14:28	NaN	NaN	NaN	NaN	NaN	NaN	1	PA
1783	91	1/4/2021 13:12	NaN	NaN	main/contact/	desktop	Chrome	www.google.com	0	MO
1784	26	1/4/2021 8:45	NaN	NaN	NaN	NaN	NaN	NaN	0	PA

1785 rows × 10 columns

In [6]:

```
#convert start time to month and hour variables
calls_subset['Month'] = calls_subset['Start Time'].apply(lambda x: x.split(' ')[0].split('/')[0])
calls_subset['Hour'] = calls_subset['Start Time'].apply(lambda x: x.split(' ')[1].split(':')[0])
calls_subset = calls_subset.drop('Start Time', axis=1)
calls_subset
```

Out[6]:

	Duration	Keywords	Campaign	Page	Device Type	Browser	Referrer	sale	State	Month	Hour
0	167	NaN	NaN	main/estate-planning-ppc/	mobile	Chrome	www.google.com	0	PA	12	12
1	115	NaN	Medicaid - Elder Law - 001	NaN	NaN	NaN	NaN	0	IA	12	12
2	106	NaN	NaN	main/	desktop	Chrome	direct	0	PA	12	12

	Duration	Keywords	Campaign	Page	Device Type	Browser	Referrer	sale	State	Month	Hour
3	33	NaN	NaN	NaN	NaN	NaN	NaN	0	PA	12	12
4	112	NaN	NaN	NaN	NaN	NaN	NaN	0	CA	12	11
...	...	...	...	...	...	...	...	...	...	...	...
1780	18	NaN	NaN	NaN	NaN	NaN	NaN	0	PA	1	8
1781	44	power of attorney will	Estate Planning 005	main/estate-planning-ppc/	desktop	Chrome	www.google.com	0	NY	1	8
1782	188	NaN	NaN	NaN	NaN	NaN	NaN	1	PA	1	14
1783	91	NaN	NaN	main/contact/	desktop	Chrome	www.google.com	0	MO	1	13
1784	26	NaN	NaN	NaN	NaN	NaN	NaN	0	PA	1	8

1785 rows × 11 columns

In [7]:

```
#remove rows without full data
calls_noNa = calls_subset.dropna().reset_index(drop=True)
print('Number of records: ' + str(calls_noNa.shape[0]))
print('Number of records with sale: ' + str(calls_noNa[calls_noNa['sale'] ==
1].reset_index().shape[0]))
```

```
Number of records: 401
Number of records with sale: 48
```

Get Dummies

In [8]:

```
#get raw value counts for variables
#for i in ['Keywords', 'Campaign', 'Page', 'Device Type', 'Browser',
'Referrer']:
#    print(calls_noNa[i].value_counts())
```

In [9]:

```
#update keyword categories to include at least 15 per category
keyword_categories = ['probate and estate administration lawyers',
'medicaid planning attorney',
'pittsburgh probate lawyers',
'elder law attorney',
'estate administration lawyer near me',
'pennsylvania lawyers']
calls_noNa['Keywords Categories'] = calls_noNa['Keywords']
calls_noNa.loc[~calls_noNa['Keywords'].isin(keyword_categories), 'Keywords
Categories'] = 'Other Keywords'
calls_noNa = calls_noNa.drop('Keywords', axis=1)
calls_noNa['Keywords Categories'].value_counts()
```

Out[9]:

```
Other Keywords                          288
```

```
probate and estate administration lawyers     25
medicaid planning attorney                    22
pittsburgh probate lawyers                    20
elder law attorney                            16
estate administration lawyer near me          15
pennsylvania lawyers                          15
Name: Keywords Categories, dtype: int64
```

In [10]:

```
#update page categories to include at least 15 per category
page_categories = ['elder-law-ppc/',
'estate-planning-ppc/',
'estate-admin-ppc/',
'main/',
'main/pittsburgh-estate-planning-lawyer/power-of-attorney-pittsburgh-pa/',
'main/firstname-redacted/',
'main/contact/']

calls_noNa['Page Categories'] = calls_noNa['Page']
calls_noNa.loc[~calls_noNa['Page'].isin(page_categories), 'Page Categories']
= 'Other Page'
calls_noNa = calls_noNa.drop('Page', axis=1)
calls_noNa['Page Categories'].value_counts()
```

Out[10]:

```
Other Page
322
main/
28
main/pittsburgh-estate-planning-lawyer/power-of-attorney-pittsburgh-pa/
19
main/contact/
16
main/firstname-redacted/
16
Name: Page Categories, dtype: int64
```

In [11]:

```
#update browser categories to include at least 10 per category
browser_categories = ['Chrome', 'Safari']
calls_noNa['Browser Categories'] = calls_noNa['Browser']
calls_noNa.loc[~calls_noNa['Browser'].isin(browser_categories), 'Browser
Categories'] = 'Firefox or Opera'
calls_noNa = calls_noNa.drop('Browser', axis=1)
calls_noNa['Browser Categories'].value_counts()
```

Out[11]:

```
Chrome              214
Safari              176
Firefox or Opera     11
```

```
Name: Browser Categories, dtype: int64
```

In [12]:

```
#reduce state categories to PA or not PA
calls_noNa['State Categories'] = calls_noNa['State']
calls_noNa.loc[calls_noNa['State'] != 'PA', 'State Categories'] = 'Not PA'
calls_noNa = calls_noNa.drop('State', axis=1)
calls_noNa['State Categories'].value_counts()
```

Out[12]:

```
PA        312
Not PA     89
Name: State Categories, dtype: int64
```

In [13]:

```
#lump all google values
calls_noNa.loc[calls_noNa['Referrer'] == 'cse.google.com', 'Referrer'] =
'www.google.com'
```

In [14]:

```
categorical = ['Keywords Categories', 'Campaign', 'Page Categories', 'Device
Type', 'Browser Categories', 'Referrer', 'State Categories']
for i in categorical:
    dummies = pd.get_dummies(calls_noNa[i], drop_first=True)
    calls_noNa =
pd.concat([calls_noNa,dummies],axis=1).dropna().reset_index(drop=True)
    calls_noNa = calls_noNa.drop(i, axis=1)
calls_noNa = calls_noNa.astype(int)
```

In [15]:

```
#check for and fix multicollinearity

vif_df = pd.DataFrame()
vif_df["feature"] = calls_noNa.columns
vif_df["VIF"] = [variance_inflation_factor(calls_noNa.values, i)
                          for i in range(len(calls_noNa.columns))]

print(vif_df)
print('\n')

calls_noNa = calls_noNa.drop('Hour', axis=1)
calls_noNa = calls_noNa.drop('www.google.com', axis=1)

vif_df = pd.DataFrame()
vif_df["feature"] = calls_noNa.columns
vif_df["VIF"] = [variance_inflation_factor(calls_noNa.values, i)
                          for i in range(len(calls_noNa.columns))]

print(vif_df)
```

```
                                              feature        VIF
0                                            Duration   1.795709
```

1	sale	2.022827
2	Month	5.896868
3	Hour	13.241278
4	elder law attorney	1.213769
5	estate administration lawyer near me	1.554053
6	medicaid planning attorney	2.514512
7	pennsylvania lawyers	1.176284
8	pittsburgh probate lawyers	1.332965
9	probate and estate administration lawyers	1.351594
10	Estate Admin - Overall	1.555531
11	Estate Planning 005	3.392152
12	Medicaid - Elder Law - 001	3.481524
13	main/	2.136406
14	main/contact/	1.128137
15	main/firstname-redacted/	1.110253
16	main/pittsburgh-estate-planning-lawyer/power-o...	1.133315
17	mobile	4.683881
18	Firefox or Opera	1.175070
19	Safari	2.183395
20	www.google.com	11.865052
21	PA	4.678496

	feature	VIF
0	Duration	1.734367
1	sale	2.019141
2	Month	4.904542
3	elder law attorney	1.213154
4	estate administration lawyer near me	1.506437
5	medicaid planning attorney	2.483177
6	pennsylvania lawyers	1.171927
7	pittsburgh probate lawyers	1.291661
8	probate and estate administration lawyers	1.295143
9	Estate Admin - Overall	1.554796
10	Estate Planning 005	2.825811
11	Medicaid - Elder Law - 001	3.062890
12	main/	2.127636
13	main/contact/	1.119803
14	main/firstname-redacted/	1.106895
15	main/pittsburgh-estate-planning-lawyer/power-o...	1.124290
16	mobile	4.275562
17	Firefox or Opera	1.132177
18	Safari	2.144722
19	PA	4.038887

Perform Analysis

Feature Selection

In [16]:

```
def feature_selection(X,y,model,cv,score):

    features_names=pd.DataFrame(X.columns)

    #perform RFECV and fit model to get rankings
    rfecv = RFECV(model, step=1, cv=cv, scoring=score)
    fitted_values=rfecv.fit(X,y)
    ranks=pd.DataFrame(fitted_values.ranking_)

    rank=pd.concat([features_names,ranks], axis=1)
    rank.columns = ["Feature", "Rank"]

    #Select rank 1's
    most_important = rank.loc[rank['Rank'] ==1]
    most_important = most_important['Feature']

    print('Most important features ('+str(len(most_important))+')')
    print(str(most_important))

    return most_important
```

Analysis

In [17]:

```
def run_lr_model_split(df, n=5, score='f1', random_state=56):

    cv = StratifiedKFold(n_splits=n)

    #split dataset into dependent and independent variables
    features = list(df.columns)  #all columns but sale
    features.remove('sale')
    X = df[features].astype('category') # Features
    y = df['sale'] # independent var

    # split X and y into test and train
    X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.2,
random_state=random_state)

    # instantiate the model
```

```
    model = LogisticRegression(max_iter=10000)

    # fit the model
    model.fit(X_train,y_train)

    #predict
    y_pred=model.predict(X_test)

    #create confusion matrix
    cMat = metrics.confusion_matrix(y_test, y_pred)

    print(cMat)

    print('Accuracy score with train/test: %.3f' %
metrics.accuracy_score(y_test, model.predict(X_test))) #model accuracy
    print('Balanced Accuracy score with train/test: %.3f' %
metrics.balanced_accuracy_score(y_test, model.predict(X_test))) #balanced
model accuracy
    print('F1 score with train/test: %.3f' % metrics.f1_score(y_test,
model.predict(X_test))) #model accuracy
    print('ROC AUC with train/test: %.3f' % metrics.accuracy_score(y_test,
model.predict(X_test))) #model accuracy

    #metrics
    y_pred_prb = model.predict_proba(X_test)[::,1]
    fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_prb)

    #ROC curve plot
    plt.plot(fpr,tpr)
    plt.ylabel('True Positive Rate')
    plt.xlabel('False Positive Rate')
    plt.show()
```

In [18]:

```
def run_lr_model_cv(df, n=5, score='f1', random_state=56):

    cv = StratifiedKFold(n_splits=n)

    #split dataset into dependent and independent variables
    features = list(df.columns)  #all columns but sale
    features.remove('sale')
    X = df[features].astype('category') # Features
    y = df['sale'] # independent var

    # instantiate the model
    model = LogisticRegression(max_iter=10000)
```

```
    #Setting the range for class weights
    weights = np.linspace(0.0,0.99,100)
    #Creating a dictionary grid for grid search
    param_grid = {'class_weight': [{0:x, 1:1.0-x} for x in weights]}

    #Fitting grid search to the train data with cv to find class weights
    gridsearch = GridSearchCV(estimator= model,
                          param_grid= param_grid,
                          cv=cv,
                          n_jobs=-1,
                          scoring=score,
                          verbose=2).fit(X, y)

    weight_df = pd.DataFrame({ 'score':
gridsearch.cv_results_['mean_test_score'], 'weight': (1- weights)})
    optimum_weight = max(weight_df[weight_df['score'] ==
max(weight_df['score'])]['weight'])

    # re-instantiate the model
    model = LogisticRegression(max_iter=10000, random_state=random_state,
                                      class_weight={0: 1-optimum_weight, 1:
optimum_weight})

    #perform feature selection
    Best_X_Columns = feature_selection(X,y,model,n,score)
    X = X[Best_X_Columns]

    # fit the model
    #model.fit(X_train,y_train)

    #predict
    #y_pred=model.predict(X_test)

    # evaluate model with k-fold validation
    scores = cross_val_score(model, X, y, scoring='accuracy', cv=cv, n_jobs=-
1)
    bal_scores = cross_val_score(model, X, y, scoring='balanced_accuracy',
cv=cv, n_jobs=-1)
    f1_scores = cross_val_score(model, X, y, scoring='f1', cv=cv, n_jobs=-1)
    w_f1_scores = cross_val_score(model, X, y, scoring='f1_weighted', cv=cv,
n_jobs=-1)
    auc_scores = cross_val_score(model, X, y, scoring='roc_auc', cv=cv,
n_jobs=-1)

    # k-fold validiation acuracy
```

```
    print('Accuracy with K-Fold validation: %.3f' % (mean(scores)))
    print('Balanced Accuracy with K-Fold validation: %.3f' %
(mean(bal_scores)))
    print('F1-Score with K-Fold validation: %.3f' % (mean(f1_scores)))
    print('ROC AUC with K-Fold validation: %.3f' % (mean(auc_scores)))

    return model
```

In [19]:

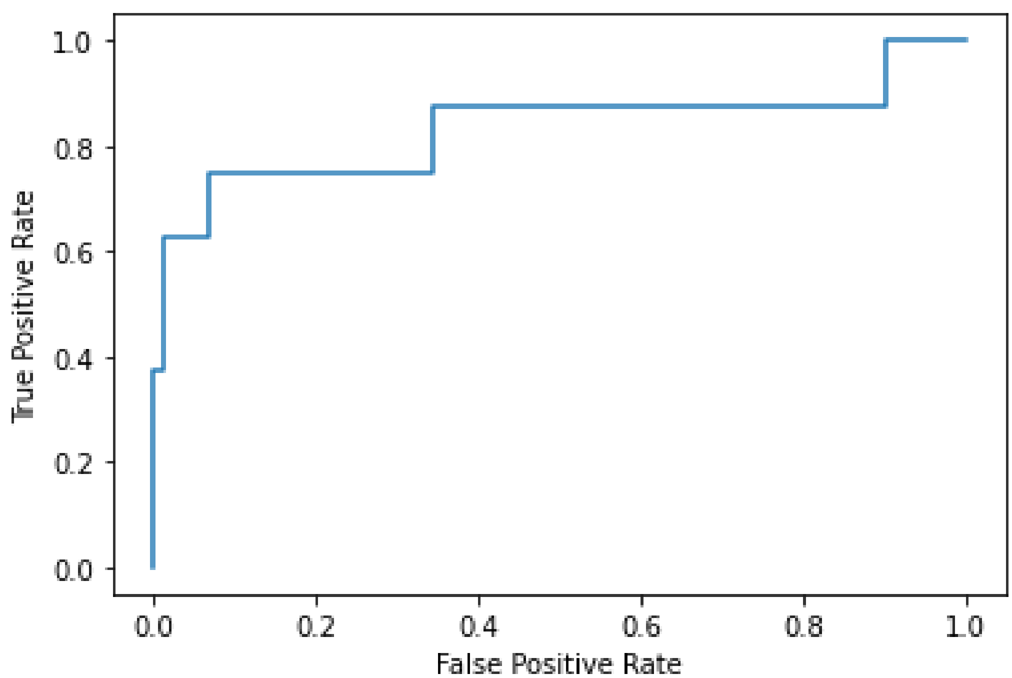
```
seed = np.random.randint(1000)
seed
```

Out[19]:

```
204
```

In [20]:

```
#linear regression, F1, CV = 5
run_lr_model_split(calls_noNa)
[[72  1]
 [ 5  3]]
Accuracy score with train/test: 0.926
Balanced Accuracy score with train/test: 0.681
F1 score with train/test: 0.500
ROC AUC with train/test: 0.926
```



In [21]:

```
#linear regression, F1, CV = 5
run_lr_model_cv(calls_noNa)
Fitting 5 folds for each of 100 candidates, totalling 500 fits
Most important features (19)
0                                              Duration
```

```
1                                                  Month
2                                     elder law attorney
3                   estate administration lawyer near me
4                              medicaid planning attorney
5                                    pennsylvania lawyers
6                              pittsburgh probate lawyers
7              probate and estate administration lawyers
8                                  Estate Admin - Overall
9                                     Estate Planning 005
10                           Medicaid - Elder Law - 001
11                                                 main/
12                                         main/contact/
13                             main/firstname-redacted/
14    main/pittsburgh-estate-planning-lawyer/power-o...
15                                                mobile
16                                      Firefox or Opera
17                                                Safari
18                                                    PA
Name: Feature, dtype: object
Accuracy with K-Fold validation: 0.918
Balanced Accuracy with K-Fold validation: 0.719
F1-Score with K-Fold validation: 0.576
ROC AUC with K-Fold validation: 0.877
```

Out[21]:

```
LogisticRegression(class_weight={0: 0.4, 1: 0.6}, max_iter=10000,
                   random_state=56)
```

In [22]:

```
#linear regression, F1, CV = 10
run_lr_model_cv(calls_noNa, n=10)
```

```
Fitting 10 folds for each of 100 candidates, totalling 1000 fits
Most important features (19)
0                                               Duration
1                                                  Month
2                                     elder law attorney
3                   estate administration lawyer near me
4                              medicaid planning attorney
5                                    pennsylvania lawyers
6                              pittsburgh probate lawyers
7              probate and estate administration lawyers
8                                  Estate Admin - Overall
9                                     Estate Planning 005
10                           Medicaid - Elder Law - 001
11                                                 main/
12                                         main/contact/
13                             main/firstname-redacted/
14    main/pittsburgh-estate-planning-lawyer/power-o...
```

```
15                                                     mobile
16                                           Firefox or Opera
17                                                     Safari
18                                                         PA
Name: Feature, dtype: object
Accuracy with K-Fold validation: 0.898
Balanced Accuracy with K-Fold validation: 0.788
F1-Score with K-Fold validation: 0.562
ROC AUC with K-Fold validation: 0.897
```

Out[22]:

```
LogisticRegression(class_weight={0: 0.19999999999999996, 1: 0.8},
                   max_iter=10000, random_state=56)
```

In [23]:

```
def run_rf_model(df, n=5, score='f1', random_state=56):

    cv = StratifiedKFold(n_splits=n)

    #split dataset into dependent and independent variables
    features = list(df.columns)  #all columns but sale
    features.remove('sale')
    X = df[features].astype('category') # Features
    y = df['sale'] # independent var

    # instantiate the model
    model = RandomForestClassifier(random_state=random_state)

    # Number of trees in random forest
    n_estimators = [int(x) for x in np.linspace(50, 2000, num = 20)] # The
number of trees in the forest.
    max_features = ['auto', 'sqrt'] # The number of features to consider when
looking for the best split
    max_depth = [int(x) for x in np.linspace(20, 120, num = 10)] # The
maximum depth of the tree.
    min_samples_split = [2, 4, 6, 8, 10] # The minimum number of samples
required to split an internal node
    min_samples_leaf = [1, 2, 3, 4, 5] # The minimum number of samples
required to be at a leaf node.
    bootstrap = [True, False] # Whether bootstrap samples are used when
building trees.

    random_grid = {'n_estimators': n_estimators,
    'max_features': max_features,
    'max_depth': max_depth,
    'min_samples_split': min_samples_split,
    'min_samples_leaf': min_samples_leaf,
    'bootstrap': bootstrap}
```

```
    # Create the random grid
    param_grid = {'n_estimators': n_estimators,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf}
    model = RandomizedSearchCV(estimator = model, param_distributions =
param_grid, cv = 5,
                                   verbose=2, n_jobs = -1, n_iter = 250,
scoring='f1')

    # fit the model
    model.fit(X,y)
    print(model.best_params_)

    # evaluate model with k-fold validation
    scores = cross_val_score(model, X, y, scoring='accuracy', cv=cv, n_jobs=-
1)
    bal_scores = cross_val_score(model, X, y, scoring='balanced_accuracy',
cv=cv, n_jobs=-1)
    f1_scores = cross_val_score(model, X, y, scoring='f1', cv=cv, n_jobs=-1)
    w_f1_scores = cross_val_score(model, X, y, scoring='f1_weighted', cv=cv,
n_jobs=-1)
    auc_scores = cross_val_score(model, X, y, scoring='roc_auc', cv=cv,
n_jobs=-1)

    # k-fold validiation acuracy
    print('Accuracy with K-Fold validation: %.3f' % (mean(scores)))
    print('Balanced Accuracy with K-Fold validation: %.3f' %
(mean(bal_scores)))
    print('F1-Score with K-Fold validation: %.3f' % (mean(f1_scores)))
    print('ROC AUC with K-Fold validation: %.3f' % (mean(auc_scores)))
```

In [69]:

```
#random forest model, f1, CV = 5
run_rf_model(calls_noNa, n=5, score='f1', random_state=56)
Fitting 5 folds for each of 250 candidates, totalling 1250 fits
{'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 3,
'max_depth': 97}
Accuracy with K-Fold validation: 0.895
Balanced Accuracy with K-Fold validation: 0.728
F1-Score with K-Fold validation: 0.510
ROC AUC with K-Fold validation: 0.843
```

In [ ]:

In [ ]: