In [27]:

```
# import packages
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

import string
import random

from sklearn.preprocessing import StandardScaler
from itertools import product
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import RepeatedStratifiedKFold

from sklearn import tree
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import KFold
from sklearn.metrics import classification_report
from sklearn.metrics import accuracy_score
from sklearn.preprocessing import OneHotEncoder, LabelEncoder
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeRegressor, DecisionTreeClassifier
from sklearn.model_selection import train_test_split

from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import GradientBoostingClassifier

import sklearn.metrics as metrics

from matplotlib import pyplot
from matplotlib.pyplot import figure

from sklearn.model_selection import RandomizedSearchCV

from sklearn.model_selection import GridSearchCV
from xgboost import XGBClassifier

from scipy.stats import loguniform
from sklearn import metrics

from sklearn.ensemble import AdaBoostClassifier
from sklearn.feature_selection import RFE

import time
import datetime

from tqdm import tqdm

from imblearn.ensemble import EasyEnsembleClassifier

from imblearn.ensemble import RUSBoostClassifier

from imblearn.datasets import make_imbalance

from sklearn.model_selection import cross_validate

from sklearn.dummy import DummyClassifier

from imblearn.ensemble import BalancedRandomForestClassifier

import warnings
from sklearn.exceptions import ConvergenceWarning

from imblearn.ensemble import BalancedBaggingClassifier
from imblearn.over_sampling import SMOTE

from sklearn.ensemble import HistGradientBoostingClassifier
def fxn():
    warnings.warn("deprecated", DeprecationWarning)
    warnings.warn("future", FutureWarning)
    warnings.warn("converagence", ConvergenceWarning)

with warnings.catch_warnings():
    warnings.simplefilter("ignore")
    fxn()

from sklearn import *
```

Initialization

In [2]:

```
# set up google cloud to store the future records of hypertune
import gspread
sa = gspread.service_account(filename="kaggle-hypertune-records-1d18a6abfb85.json")
```

In [98]:

```
# import data
train_data = pd.read_csv('train.csv')
test_data = pd.read_csv('test.csv')
sample_submission_data = pd.read_csv('sample_submission.csv')
```

In [99]:

```
# basic information
train_data.info()

# describe the data
train_data.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1340 entries, 0 to 1339
Data columns (total 35 columns):
 #   Column                    Non-Null Count  Dtype 
---  ------                    --------------  ----- 
 0   EmployeeID                1340 non-null   int64 
 1   Age                       1340 non-null   int64 
 2   Attrition                 1340 non-null   object
 3   BusinessTravel            1340 non-null   object
 4   DailyRate                 1340 non-null   int64 
 5   Department                1340 non-null   object
 6   DistanceFromHome          1340 non-null   int64 
 7   Education                 1340 non-null   int64 
 8   EducationField            1340 non-null   object
 9   EmployeeCount             1340 non-null   int64 
 10  EnvironmentSatisfaction   1340 non-null   int64 
 11  Gender                    1340 non-null   object
 12  HourlyRate                1340 non-null   int64 
 13  JobInvolvement            1340 non-null   int64 
 14  JobLevel                  1340 non-null   int64 
 15  JobRole                   1340 non-null   object
 16  JobSatisfaction           1340 non-null   int64 
 17  MaritalStatus             1340 non-null   object
 18  MonthlyIncome             1340 non-null   int64 
 19  MonthlyRate               1340 non-null   int64 
 20  NumCompaniesWorked        1340 non-null   int64 
 21  Over18                    1340 non-null   object
 22  OverTime                  1340 non-null   object
 23  PercentSalaryHike         1340 non-null   int64
 24  PerformanceRating         1340 non-null   int64
 25  RelationshipSatisfaction  1340 non-null   int64
 26  StandardHours             1340 non-null   int64
 27  Shift                     1340 non-null   int64
 28  TotalWorkingYears         1340 non-null   int64
 29  TrainingTimesLastYear     1340 non-null   int64
 30  WorkLifeBalance           1340 non-null   int64
 31  YearsAtCompany            1340 non-null   int64
 32  YearsInCurrentRole        1340 non-null   int64
 33  YearsSinceLastPromotion   1340 non-null   int64
 34  YearsWithCurrManager      1340 non-null   int64
dtypes: int64(26), object(9)
memory usage: 366.5+ KB
```

Out[99]:

	EmployeeID	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	Educ
0	1317087	40	No	Travel_Rarely	1398	Cardiology	2	4	Li
1	1548175	40	No	Travel_Rarely	1300	Maternity	24	2	
2	1215433	25	No	Travel_Rarely	622	Cardiology	13	1	
3	1375351	33	No	Travel_Rarely	922	Maternity	1	5	
4	1028734	39	No	Travel_Frequently	505	Maternity	2	4	

5 rows × 35 columns

In [100…

```
# check for missing data
train_data.isnull().sum()
test_data.isnull().sum()
# there is no missing data
```

Out[100…

```
EmployeeID                  0
Age                         0
BusinessTravel              0
DailyRate                   0
Department                  0
DistanceFromHome            0
Education                   0
EducationField              0
EmployeeCount               0
EnvironmentSatisfaction     0
Gender                      0
HourlyRate                  0
JobInvolvement              0
JobLevel                    0
JobRole                     0
JobSatisfaction             0
MaritalStatus               0
MonthlyIncome               0
MonthlyRate                 0
NumCompaniesWorked          0
Over18                      0
OverTime                    0
PercentSalaryHike           0
PerformanceRating           0
RelationshipSatisfaction    0
StandardHours               0
Shift                       0
TotalWorkingYears           0
TrainingTimesLastYear       0
WorkLifeBalance             0
```

```
YearsAtCompany             0
YearsInCurrentRole         0
YearsSinceLastPromotion    0
YearsWithCurrManager       0
dtype: int64
```

In [6]:

```
# check for duplicated data
train_data.duplicated().sum()
train_data.duplicated().sum()
```

Out[6]:

```
0
```

In [82]:

```
# feature engineering
# Categorical -> Numerical

def quantifyCategoricalTest(dataset):
    dataset = pd.get_dummies(dataset, columns=["Department","EducationField","JobRole","Ma
    dataset['BusinessTravel'].replace(['Non-Travel','Travel_Rarely', 'Travel_Frequently'],
    dataset['Gender'].replace(['Female', 'Male'], [0, 1], inplace=True)
    dataset['Over18'].replace(['N', 'Y'], [0, 1], inplace=True)
    dataset['OverTime'].replace(['No', 'Yes'], [0, 1], inplace=True)

    return dataset

def quantifyCategoricalTrain(dataset):
    dataset = quantifyCategoricalTest(dataset)
    dataset['Attrition'].replace(['No', 'Yes'], [0, 1], inplace=True)

    return dataset
```

In [101…

```
train_data = quantifyCategoricalTrain(train_data)
test_data = quantifyCategoricalTest(test_data)
```

In [102…

```
# drop data
train_data = train_data.drop(['EmployeeID','EmployeeCount', 'Over18', 'StandardHours'], ax
test_data = test_data.drop(['EmployeeID','EmployeeCount', 'Over18', 'StandardHours'], axis
```

In [10]:

```
train_data.head()
```

Out[10]:

	Age	Attrition	BusinessTravel	DailyRate	DistanceFromHome	Education	EnvironmentSatisfaction	Gender
0	40	0	1	1398	2	4	3	0
1	40	0	1	1300	24	2	1	1
2	25	0	1	622	13	1	2	1
3	33	0	1	922	1	5	1	0
4	39	0	2	505	2	4	3	0

5 rows × 40 columns

In [11]:

```
train_data.describe()
```

Out[11]:

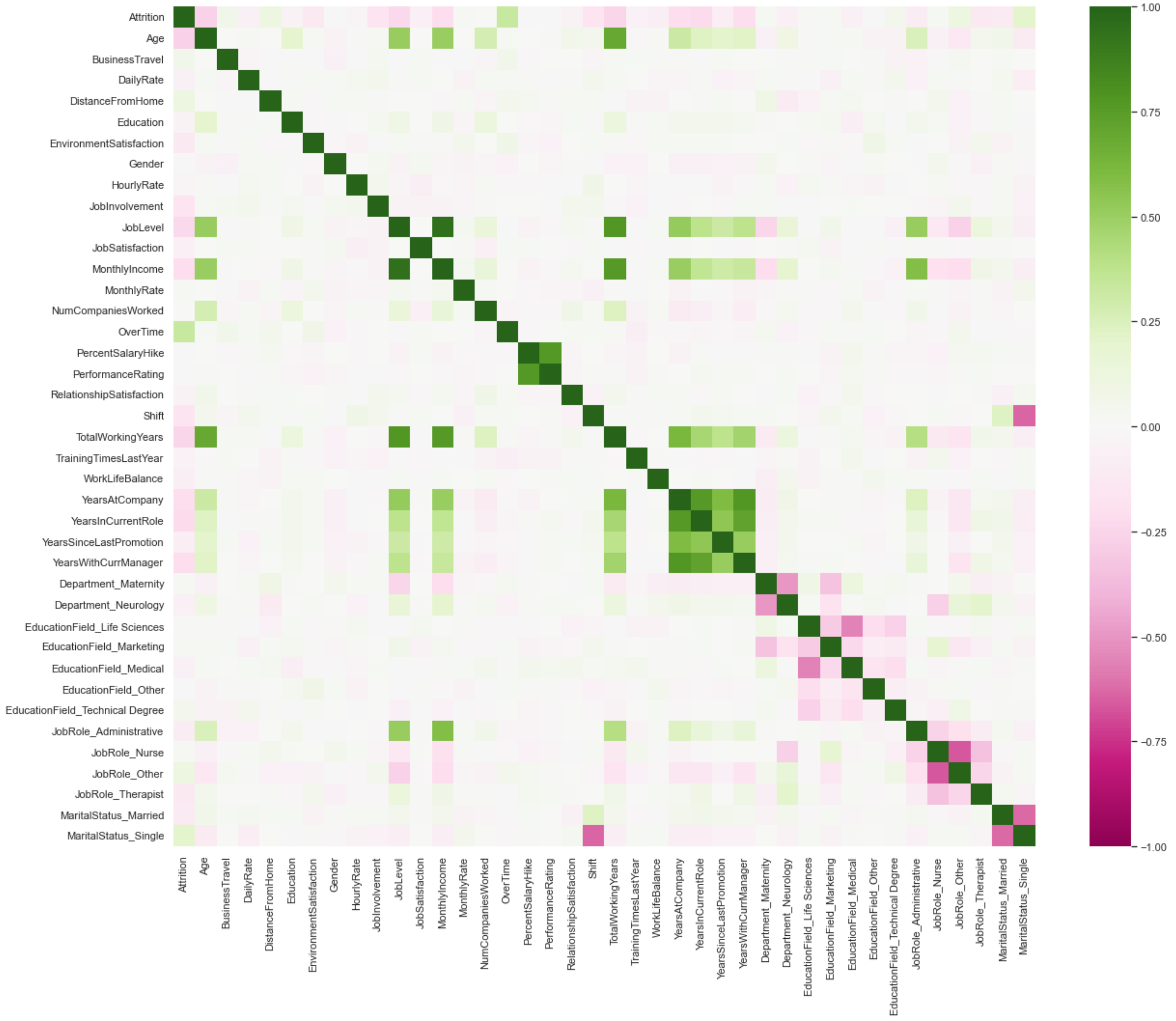
	Age	Attrition	BusinessTravel	DailyRate	DistanceFromHome	Education	Environme

	Age	Attrition	BusinessTravel	DailyRate	DistanceFromHome	Education	Environme
count	1340.000000	1340.000000	1340.000000	1340.000000	1340.000000	1340.000000	
mean	36.580597	0.118657	1.092537	799.197761	9.193284	2.924627	
std	9.013072	0.323505	0.534490	399.333256	8.141621	1.036088	
min	18.000000	0.000000	0.000000	102.000000	1.000000	1.000000	
25%	30.000000	0.000000	1.000000	465.000000	2.000000	2.000000	
50%	35.000000	0.000000	1.000000	796.000000	7.000000	3.000000	
75%	42.000000	0.000000	1.000000	1153.000000	14.000000	4.000000	
max	60.000000	1.000000	2.000000	1499.000000	29.000000	5.000000	

8 rows × 40 columns

In [103…

```
attrition = train_data.pop('Attrition')
train_data.insert(0, 'Attrition', attrition)

correlation_matrix = train_data.corr().round(2)
sns.heatmap(data = correlation_matrix, annot = False, cmap="PiYG", vmin=-1, vmax=1)
sns.set(rc = {'figure.figsize':(20,16)})
plt.show()
```

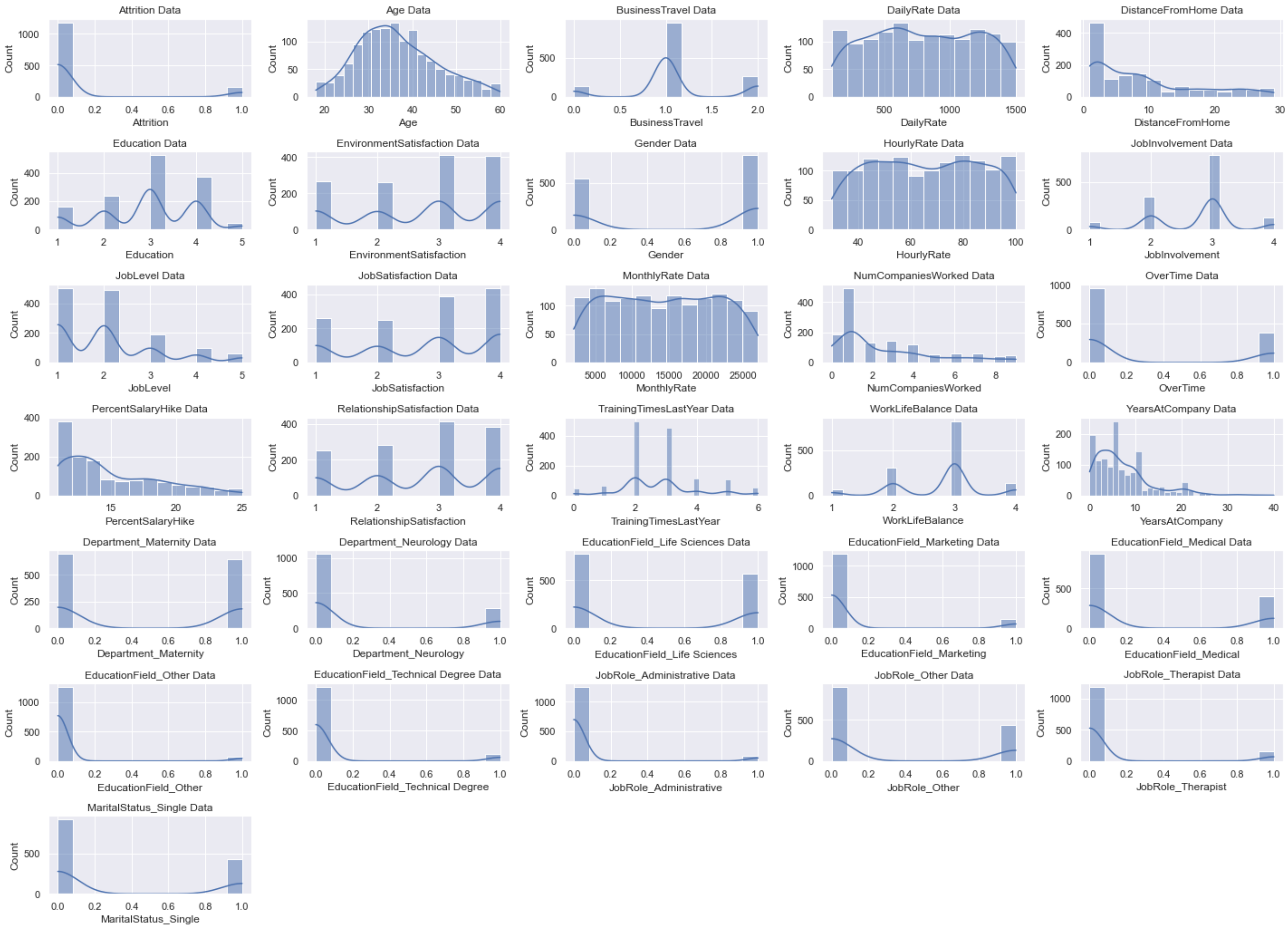


In [13]:

```
# drop data
train_data = train_data.drop(['MonthlyIncome', "TotalWorkingYears", 'PerformanceRating', '
                              'YearsSinceLastPromotion', 'YearsWithCurrManager',"JobRole_N
                              "MaritalStatus_Married","Shift"], axis=1)
test_data = test_data.drop(['MonthlyIncome', "TotalWorkingYears", 'PerformanceRating', 'Ye
                              'YearsSinceLastPromotion', 'YearsWithCurrManager',"JobRole_N
                              "MaritalStatus_Married","Shift"], axis=1)
```

In [14]:

```
# plt.figure(figsize=(12,21))
for i,col in enumerate(train_data.columns,1):
    plt.subplot(8,5,i)
    plt.title(f"{col} Data")
    sns.histplot(train_data[col],kde=True)
    plt.tight_layout()
    plt.plot()
```



In [57]:

```
# feature engineering
# log
def log_for_longtail(df):
    df['DistanceFromHome'] = np.log((1+ df['DistanceFromHome'] ))
    df['JobLevel'] = np.log((1+ df['JobLevel'] ))
    df['NumCompaniesWorked'] = np.log((1+  df['NumCompaniesWorked']))
    df['PercentSalaryHike'] = np.log((1+ df['PercentSalaryHike'] ))
    df['YearsAtCompany'] = np.log((1+ df['YearsAtCompany'] ))

    return df
```

In [104…

```
# # feature engineering
# # log
# def log_for_longtail(df):
#     df['DistanceFromHome'] = np.log((1+ df['DistanceFromHome'] ))
#     df['JobLevel'] = np.log((1+ df['JobLevel'] ))
#     df['MonthlyIncome'] = np.log((1+ df['MonthlyIncome'] ))
#     df['NumCompaniesWorked'] = np.log((1+  df['NumCompaniesWorked']))
#     df['PercentSalaryHike'] = np.log((1+ df['PercentSalaryHike'] ))
#     df['TotalWorkingYears'] = np.log((1+ df['TotalWorkingYears'] ))
#     df['YearsInCurrentRole'] = np.log((1+ df['YearsInCurrentRole'] ))
#     df['YearsAtCompany'] = np.log((1+ df['YearsAtCompany'] ))
#     df['YearsSinceLastPromotion'] = np.log((1+df['YearsSinceLastPromotion']  ))
#     df['YearsWithCurrManager'] = np.log((1+ df['YearsWithCurrManager']  ))

#     return df
```

In [105…

```
train_data = log_for_longtail(train_data)
test_data = log_for_longtail(test_data)
```

In [88]:

```
print(len(train_data.columns))
```

```
40
```

feature selection

In [106…

```
# split data into X and y (data and label)
X_nondrop = train_data.drop(columns=['Attrition'], axis = 1)
y = train_data['Attrition']
```

In [90]:

```
X_nondrop_scaled =  StandardScaler().fit_transform(X_nondrop)
```

In [48]:

```
classes_count = y.value_counts()
classes_count
```

Out[48]:

```
0    1181
1     159
Name: Attrition, dtype: int64
```

In [28]:

```
index = ['Logistic regression',
         'Random Forest',
         'Logistic regression with balanced class weights',
         'Balanced random forest',
         'Balanced bag of histogram gradient boosting']

scores = {"Accuracy": [], "Balanced accuracy": [], "f1": [], "f1_weighted":[]}

scoring = ["accuracy", "balanced_accuracy", "f1", "f1_weighted"]

clfs =  [LogisticRegression(n_jobs=-1), RandomForestClassifier(n_jobs=-1),
        LogisticRegression(class_weight="balanced", n_jobs=-1),
        BalancedRandomForestClassifier(n_jobs=-1), BalancedBaggingClassifier(
        base_estimator=HistGradientBoostingClassifier(random_state=42),
        n_jobs=-1)]
```

In [29]:

```
for i in clfs:
    cv_result = cross_validate(i, X_nondrop_scaled, y, scoring=scoring)
    scores["Accuracy"].append(cv_result["test_accuracy"].mean())
    scores["Balanced accuracy"].append(cv_result["test_balanced_accuracy"].mean())
    scores["f1"].append(cv_result["test_f1"].mean())
    scores["f1_weighted"].append(cv_result["test_f1_weighted"].mean())

df_scores = pd.DataFrame(scores, index=index)
df_scores
```

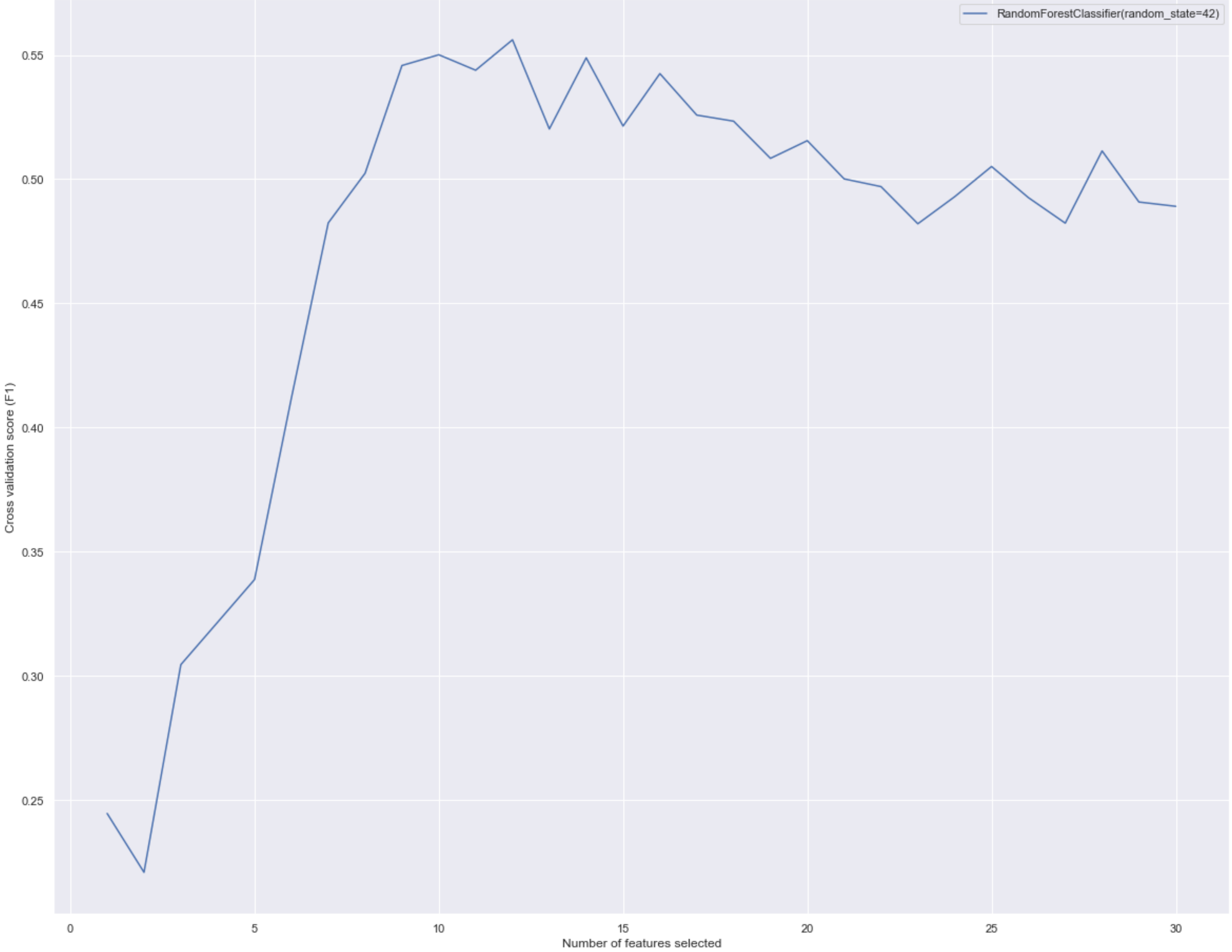
Out[29]:

	Accuracy	Balanced accuracy	f1	f1_weighted
Logistic regression	0.935821	0.806290	0.694960	0.932069
Random Forest	0.914179	0.665722	0.479481	0.896930
Logistic regression with balanced class weights	0.869403	0.866068	0.610142	0.884530
Balanced random forest	0.857463	0.859197	0.589179	0.875258
Balanced bag of histogram gradient boosting	0.895522	0.869887	0.655377	0.904842

In [30]:

```
from sklearn.pipeline import Pipeline
from numpy import mean
from numpy import std
from sklearn.model_selection import StratifiedKFold
from sklearn.model_selection import cross_val_score
from sklearn.svm import SVC

from sklearn.feature_selection import RFECV

estimator_for_feature = [RandomForestClassifier(random_state=42)]


plt.figure(figsize=(8,6))
plt.figure()
plt.xlabel("Number of features selected")
plt.ylabel("Cross validation score (F1)")

for i in estimator_for_feature:
    rfecv = RFECV(
        estimator = i,scoring = "f1", step = 1,n_jobs=-1, verbose=0,
        cv = RepeatedStratifiedKFold(n_splits=5, n_repeats= 3, random_state=42),
        min_features_to_select=1)
    rfecv.fit(X_nondrop, y)

    print("%s Optimal number of features : %d, achieving F1: %.3f" %
      (i, rfecv.n_features_, mean(rfecv.grid_scores_[rfecv.n_features_])))

    # Plot number of features VS. cross-validation scores

    plt.plot(
        range(1, len(rfecv.grid_scores_) + 1),
       [mean(j) for j in rfecv.grid_scores_], label = str(i))

plt.legend()
plt.show()
```

```
RandomForestClassifier(random_state=42) Optimal number of features : 12, achieving F1: 0.5
20

/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/utils/deprecation.py:1
03: FutureWarning: The `grid_scores_` attribute is deprecated in version 1.0 in favor of `
cv_results_` and will be removed in version 1.2.
  warnings.warn(msg, category=FutureWarning)
<Figure size 576x432 with 0 Axes>
```



In [31]:

```python
# define RFE
rfe_lg = RFE(estimator=RandomForestClassifier(random_state=42), n_features_to_select=12)

# fit RFE
rfe_lg.fit(X_nondrop, y)

# summarize all features
dict_for_feature_select_lg = dict()
dt = pd.DataFrame(columns=["Feature Name", "Selected"])

for i in range(X_nondrop.shape[1]):
    dict_for_feature_select_lg[X_nondrop.columns[i]] = rfe_lg.support_[i]
    new = [str(X_nondrop.columns[i]), str(rfe_lg.support_[i])]
    dt.loc[len(dt.index)] = new

print(dt)
```

```
                       Feature Name Selected
0                               Age     True
1                    BusinessTravel    False
2                         DailyRate     True
3                  DistanceFromHome     True
4                         Education    False
5           EnvironmentSatisfaction     True
6                            Gender    False
7                        HourlyRate     True
8                    JobInvolvement     True
9                          JobLevel     True
10                  JobSatisfaction    False
```

```
11                      MonthlyRate     True
12                NumCompaniesWorked     True
13                          OverTime     True
14                 PercentSalaryHike     True
15          RelationshipSatisfaction    False
16             TrainingTimesLastYear    False
17                   WorkLifeBalance    False
18                    YearsAtCompany     True
19             Department_Maternity    False
20             Department_Neurology    False
21      EducationField_Life Sciences    False
22          EducationField_Marketing    False
23            EducationField_Medical    False
24              EducationField_Other    False
25  EducationField_Technical Degree    False
26            JobRole_Administrative    False
27                     JobRole_Other    False
28                 JobRole_Therapist    False
29             MaritalStatus_Single    False
```

In [32]:

```
dict_for_feature_select_list = []

for col in X_nondrop.columns:
    if dict_for_feature_select_lg[col] == False:
        dict_for_feature_select_list.append(col)

X_drop = X_nondrop.drop(dict_for_feature_select_list, axis=1)

print(X_drop.shape)
```

```
(1340, 12)
```

In [107…

```
X = X_nondrop


# apply standard scaler onto the training data
scale = StandardScaler()
scale.fit(X)
X = scale.transform(X)
```

In [36]:

```
import json
from json import dumps
```

In [108…

```
# source: Matt. Validation Curve Plot from GridSearchCV Results.
# Retrieved from https://matthewbilyeu.com/blog/2019-02-05/validation-curve-plot-from-gri
import numbers
def plot_grid_search_validation_curve(grid, param_to_vary,
                                      title='Validation Curve', ylim=None,
                                      xlim=None, log=None):
    """Plots train and cross-validation scores from a GridSearchCV instance's
    best params while varying one of those params."""

    df_cv_results = pd.DataFrame(grid.cv_results_)

    print(type(df_cv_results))
    train_scores_mean = df_cv_results['mean_train_score']
    valid_scores_mean = df_cv_results['mean_test_score']
    train_scores_std = df_cv_results['std_train_score']
    valid_scores_std = df_cv_results['std_test_score']

    param_cols = [c for c in df_cv_results.columns if c[:6] == 'param_']
    param_ranges = [grid.param_grid[p[6:]] for p in param_cols]
    param_ranges_lengths = [len(pr) for pr in param_ranges]

    train_scores_mean = np.array(train_scores_mean).reshape(*param_ranges_lengths)
    valid_scores_mean = np.array(valid_scores_mean).reshape(*param_ranges_lengths)
    train_scores_std = np.array(train_scores_std).reshape(*param_ranges_lengths)
    valid_scores_std = np.array(valid_scores_std).reshape(*param_ranges_lengths)

    param_to_vary_idx = param_cols.index('param_{}'.format(param_to_vary))

    slices = []
    for idx, param in enumerate(grid.best_params_):
        if (idx == param_to_vary_idx):
            slices.append(slice(None))
            continue
        best_param_val = grid.best_params_[param]
        idx_of_best_param = 0
        if isinstance(param_ranges[idx], np.ndarray):
            idx_of_best_param = param_ranges[idx].tolist().index(best_param_val)
        else:
            idx_of_best_param = param_ranges[idx].index(best_param_val)
        slices.append(idx_of_best_param)

    train_scores_mean = train_scores_mean[tuple(slices)]
    valid_scores_mean = valid_scores_mean[tuple(slices)]
    train_scores_std = train_scores_std[tuple(slices)]
    valid_scores_std = valid_scores_std[tuple(slices)]

    plt.figure(figsize=(8,6))
    plt.clf()

    plt.title(title)
    plt.xlabel(param_to_vary)
    plt.ylabel('Score')

    if (ylim is None):
        plt.ylim(0.0, 1.1)
    else:
        plt.ylim(*ylim)

    if (not (xlim is None)):
        plt.xlim(*xlim)

    lw = 2

    plot_fn = plt.plot
    if log:
        plot_fn = plt.semilogx

    param_range = param_ranges[param_to_vary_idx]
    if (not isinstance(param_range[0], numbers.Number)):
        param_range = [str(x) for x in param_range]
    plot_fn(param_range, train_scores_mean, label='Training score', color='r',
            lw=lw)
    plt.fill_between(param_range, train_scores_mean - train_scores_std,
                     train_scores_mean + train_scores_std, alpha=0.1,
                     color='r', lw=lw)
    plot_fn(param_range, valid_scores_mean, label='Cross-validation score',
            color='b', lw=lw)
    plt.fill_between(param_range, valid_scores_mean - valid_scores_std,
                     valid_scores_mean + valid_scores_std, alpha=0.1,
                     color='b', lw=lw)

    plt.legend(loc='lower right')

    plt.show()
```

In [145…

```
# modeling
sample_weight = np.array([10 if i == 1 else 1 for i in y])
def hypertune_fit_eval(estimator, param_grid):

    grid_obj = GridSearchCV(estimator = estimator, param_grid = param_grid, return_train_s
                            cv = StratifiedKFold(), verbose=0, n_jobs = -1, scoring = "f
    start = time.time()
    grid_obj.fit(X, y)
    end = time.time()

    print("\n The best estimator:\n", grid_obj.best_estimator_)
    print("\n The best score:\n", grid_obj.best_score_)
    print("\n The best parameters:\n", grid_obj.best_params_)
    print("\n Train Time:\n", end-start)

    random_id_for_kaggle = ''.join(random.choices(string.ascii_uppercase + string.digits,
    timestamp = str(datetime.datetime.now())
    estimator = str(estimator)
    best_estimator_ = str(grid_obj.best_estimator_)
    train_time = str(end - start)
    best_f1 = str(grid_obj.best_score_)
    X_cols = dict_for_feature_select_list

    new_row = [random_id_for_kaggle, timestamp, estimator, best_estimator_,
               train_time, best_f1, X_cols]

    records = sa.open("records").worksheet("Sheet1")
    records_df = pd.DataFrame(records.get_all_records())

    nrow = len(records_df)

    for i in range(len(new_row)):
        records.update_cell(nrow+2, i+1, json.dumps(new_row[i]))

    return  grid_obj
```

Hypertune: LR

In [110…

```
# logistic regression
lr = LogisticRegression(random_state=42, class_weight="balanced")

lr_grid = {
    "solver": ['newton-cg', 'lbfgs', 'liblinear', 'sag', 'saga']
}

best_lr = hypertune_fit_eval(lr, lr_grid)
plot_grid_search_validation_curve(best_lr, 'solver', title='LogisticRegression')
```

```
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  warnings.warn(
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  warnings.warn(
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  warnings.warn(
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  warnings.warn(
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
```

```
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  warnings.warn(
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
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/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
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/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  warnings.warn(
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:3
50: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  warnings.warn(
 The best estimator:
 LogisticRegression(class_weight='balanced', random_state=42, solver='newton-cg')

 The best score:
 0.6660420007122451

 The best parameters:
 {'solver': 'newton-cg'}

 Train Time:
 0.17855310440063477
<class 'pandas.core.frame.DataFrame'>
```
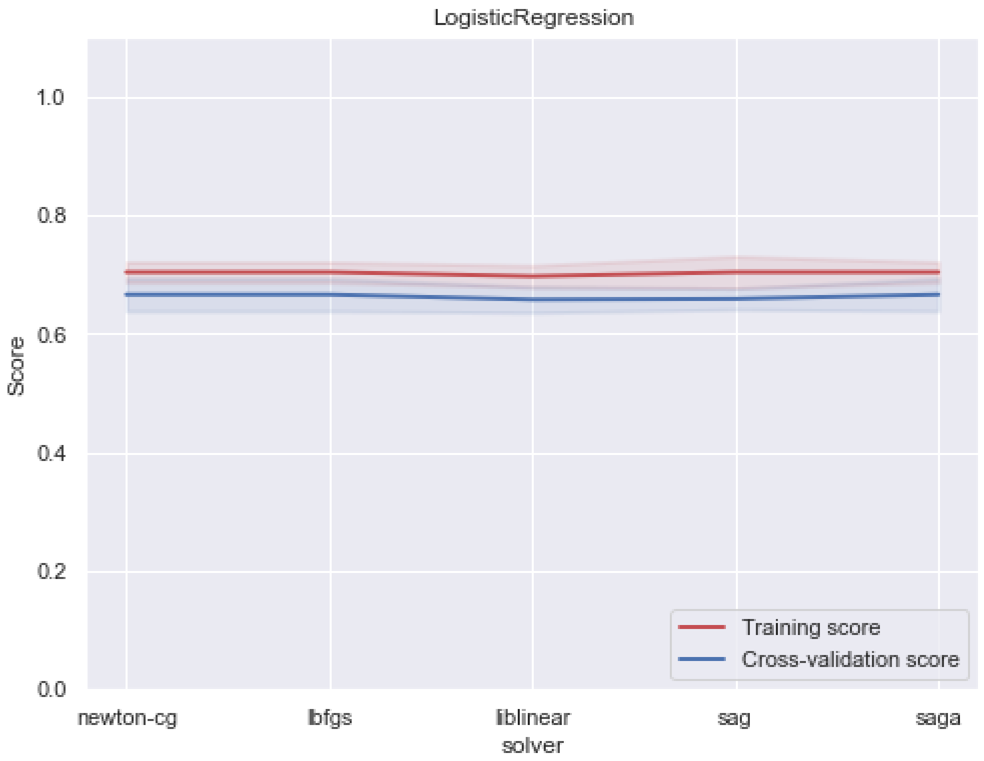
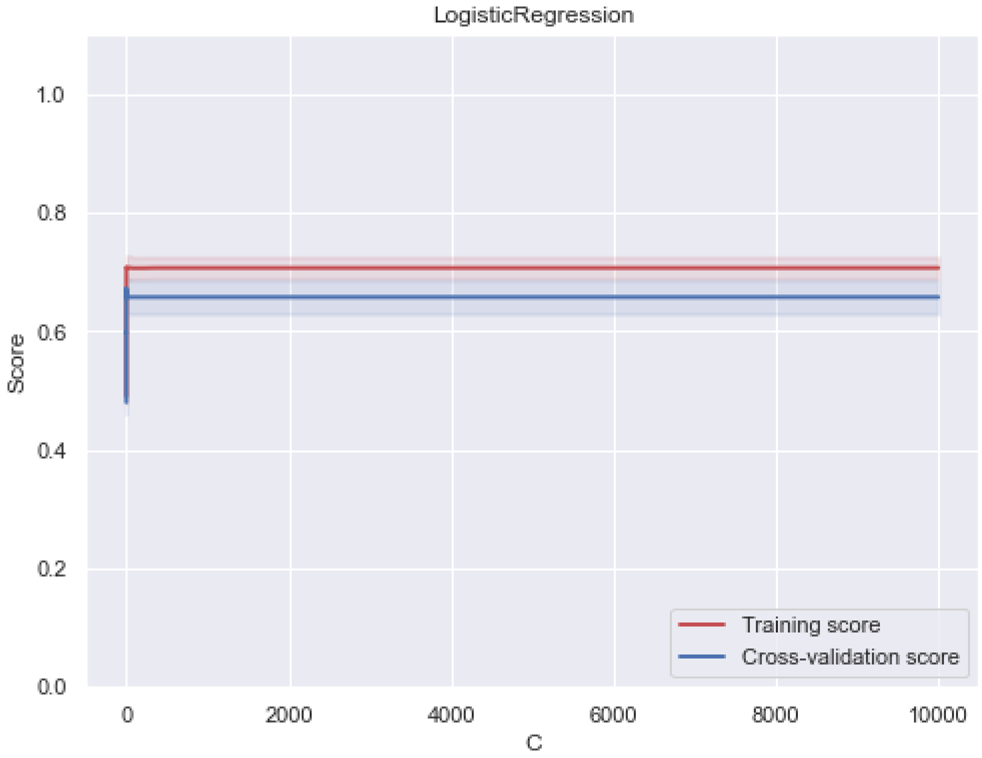



In [111…

```
# logistic regression
lr = best_lr.best_estimator_

lr_grid = {
    "C": np.logspace(-4, 4, 50)
}

best_lr = hypertune_fit_eval(lr, lr_grid)
plot_grid_search_validation_curve(best_lr, 'C', title='LogisticRegression')
```

```
The best estimator:
LogisticRegression(C=0.3906939937054613, class_weight='balanced',
                   random_state=42, solver='newton-cg')

The best score:
0.6728700486777743

The best parameters:
{'C': 0.3906939937054613}

Train Time:
0.7589290142059326
<class 'pandas.core.frame.DataFrame'>
```



In [160…

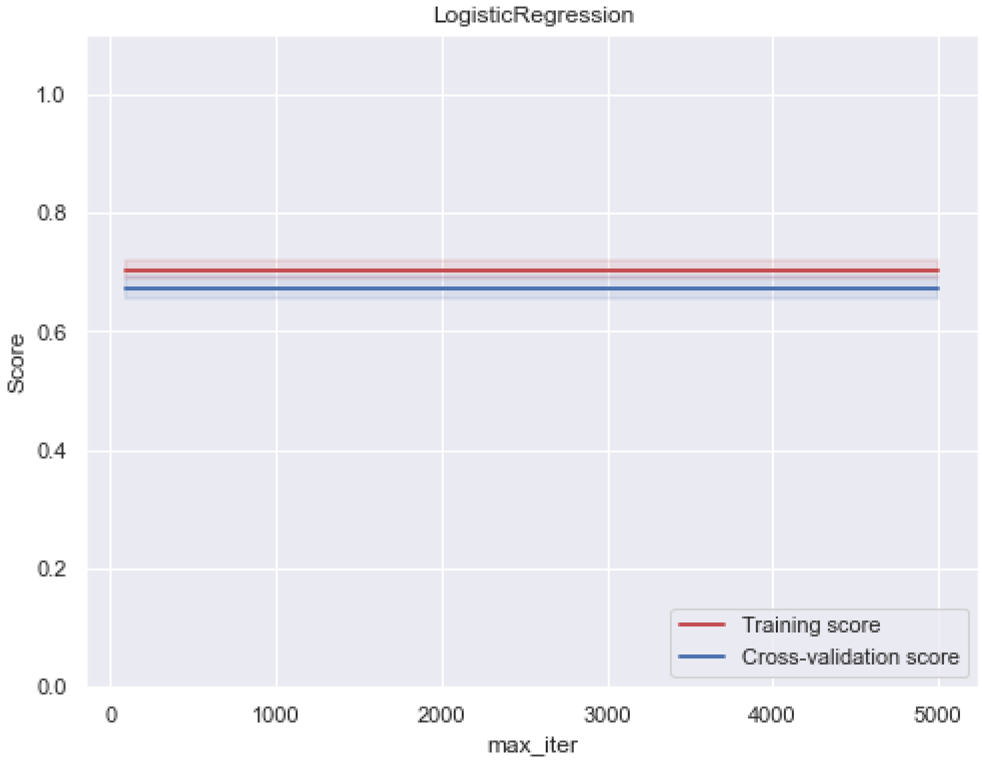
```
print(np.logspace(-4,4, 50))
```

```
[1.00000000e-04 1.45634848e-04 2.12095089e-04 3.08884360e-04
 4.49843267e-04 6.55128557e-04 9.54095476e-04 1.38949549e-03
 2.02358965e-03 2.94705170e-03 4.29193426e-03 6.25055193e-03
 9.10298178e-03 1.32571137e-02 1.93069773e-02 2.81176870e-02
 4.09491506e-02 5.96362332e-02 8.68511374e-02 1.26485522e-01
 1.84206997e-01 2.68269580e-01 3.90693994e-01 5.68986603e-01
 8.28642773e-01 1.20679264e+00 1.75751062e+00 2.55954792e+00
 3.72759372e+00 5.42867544e+00 7.90604321e+00 1.15139540e+01
 1.67683294e+01 2.44205309e+01 3.55648031e+01 5.17947468e+01
 7.54312006e+01 1.09854114e+02 1.59985872e+02 2.32995181e+02
 3.39322177e+02 4.94171336e+02 7.19685673e+02 1.04811313e+03
 1.52641797e+03 2.22299648e+03 3.23745754e+03 4.71486636e+03
 6.86648845e+03 1.00000000e+04]
```

In [113…

```
# logistic regression
lr = best_lr.best_estimator_

lr_grid = {
    'max_iter' : [100, 1000,2500, 5000]
}

best_lr = hypertune_fit_eval(lr, lr_grid)
plot_grid_search_validation_curve(best_lr, 'max_iter', title='LogisticRegression')
```

```
The best estimator:
LogisticRegression(C=0.3906939937054613, class_weight='balanced',
                   random_state=42, solver='newton-cg')

The best score:
0.6728700486777743

The best parameters:
{'max_iter': 100}

Train Time:
0.11745715141296387
<class 'pandas.core.frame.DataFrame'>
```



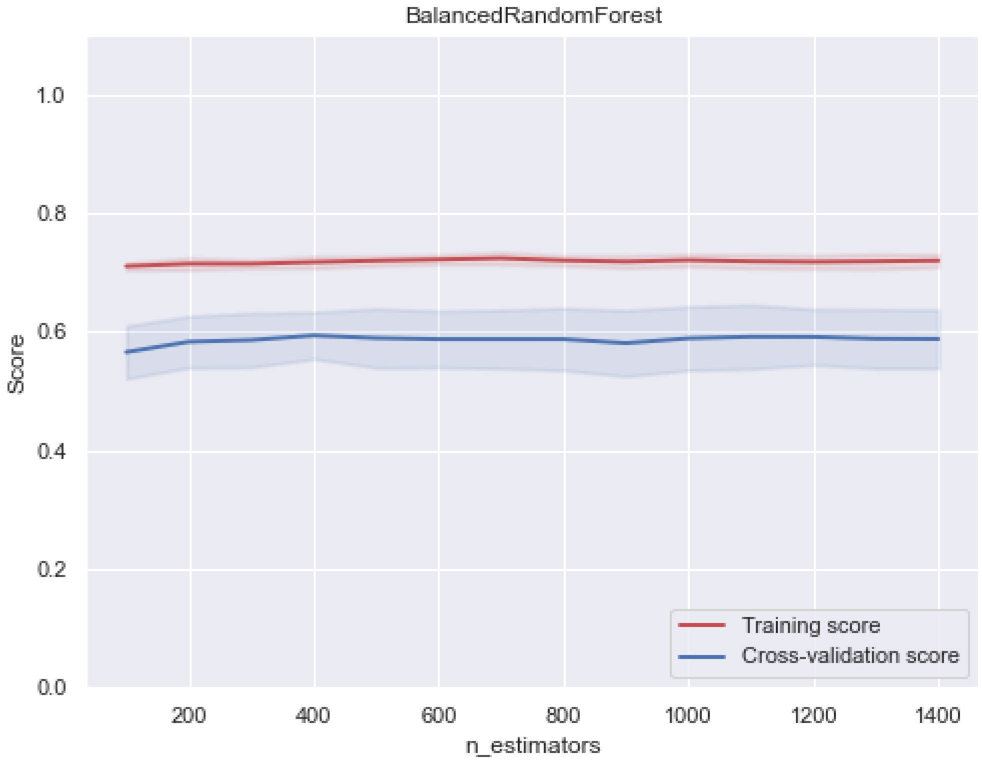
In [ ]:

```
# logistic regression
lr = best_lr.best_estimator_
lr_grid = {
    "penalty": ['l1', 'l2', 'elasticnet']
}

best_lr = hypertune_fit_eval(lr, lr_grid)
plot_grid_search_validation_curve(best_lr, 'penalty', title='LogisticRegression')
```

In [97]:

```
# brf

from imblearn.ensemble import BalancedRandomForestClassifier

# random forest
brf = BalancedRandomForestClassifier(n_jobs= -1, random_state=42)

brf_grid = {'n_estimators': np.arange(100, 1500, 100)
           }
best_brf = hypertune_fit_eval(brf, brf_grid)
plot_grid_search_validation_curve(best_brf, 'n_estimators', title='BalancedRandomForest')
```

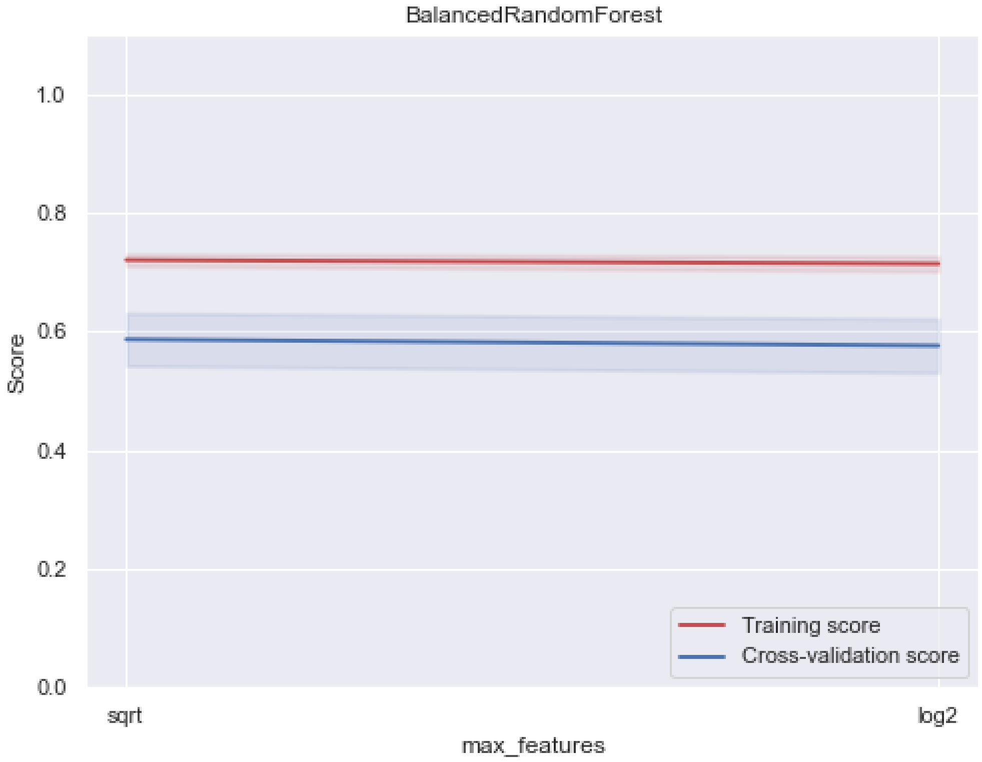
```
The best estimator:
BalancedRandomForestClassifier(n_estimators=400, n_jobs=-1, random_state=42)

The best score:
 0.5938415713675168

 The best parameters:
 {'n_estimators': 400}

 Train Time:
 30.14676809310913
<class 'pandas.core.frame.DataFrame'>
```



In [65]:

```
# brf

# random forest
brf = best_brf.best_estimator_

brf_grid = {
               'max_features': ["sqrt", "log2"],
           }
best_brf = hypertune_fit_eval(brf, brf_grid)
plot_grid_search_validation_curve(best_brf, 'max_features', title='BalancedRandomForest')
```

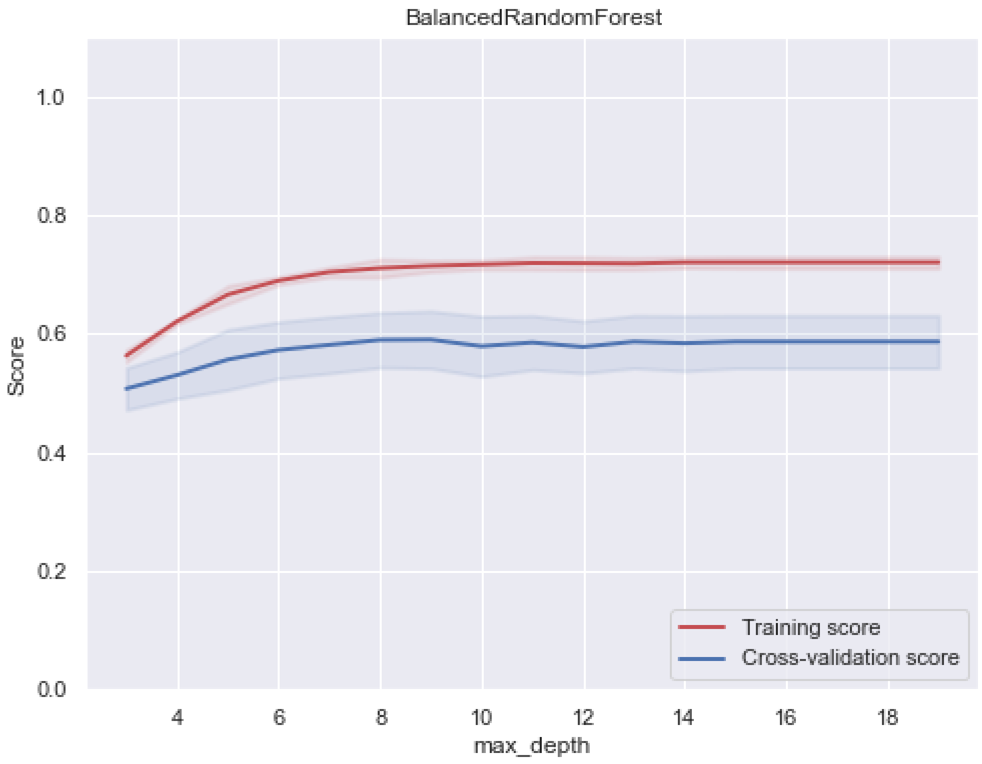
```
 The best estimator:
 BalancedRandomForestClassifier(n_estimators=500, n_jobs=-1, random_state=42)

 The best score:
 0.5866386404694979

 The best parameters:
 {'max_features': 'sqrt'}

 Train Time:
 4.356066942214966
<class 'pandas.core.frame.DataFrame'>
```



In [66]:

```
# brf

# random forest
brf = best_brf.best_estimator_

brf_grid = {
               'max_depth': np.arange(3,20,1)
           }
best_brf = hypertune_fit_eval(brf, brf_grid)
plot_grid_search_validation_curve(best_brf, 'max_depth', title='BalancedRandomForest')
```

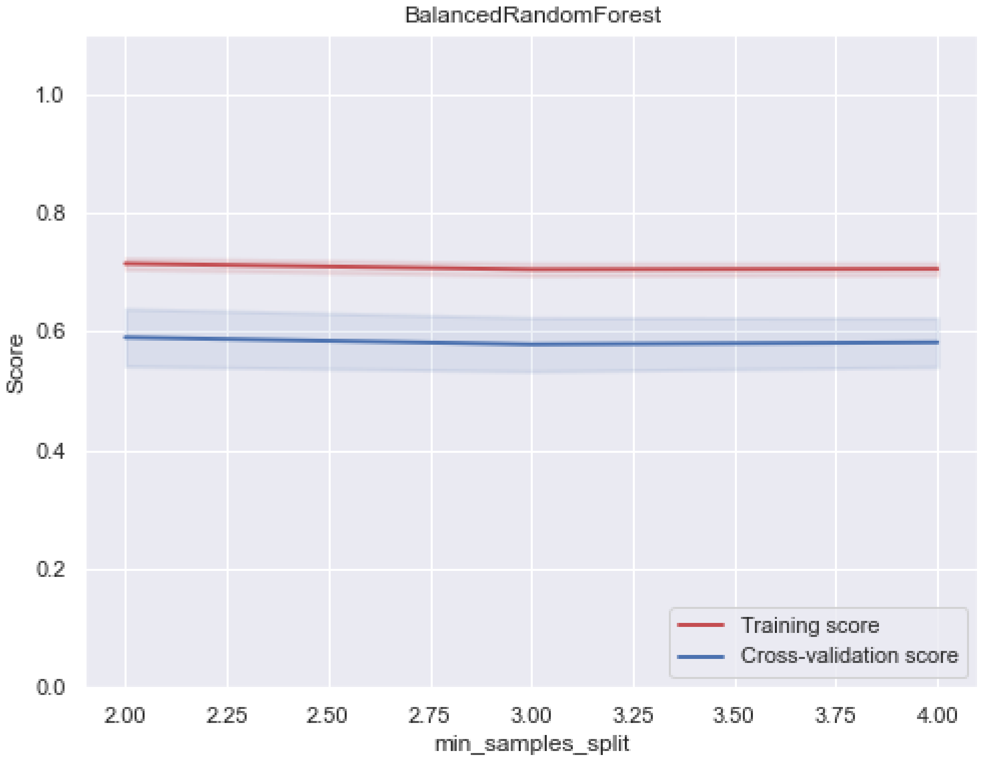
```
 The best estimator:
 BalancedRandomForestClassifier(max_depth=9, n_estimators=500, n_jobs=-1,
                                random_state=42)

 The best score:
 0.5900157351880037

 The best parameters:
 {'max_depth': 9}

 Train Time:
 24.133669137954712
<class 'pandas.core.frame.DataFrame'>
```



In [67]:

```
# brf

# random forest
brf = best_brf.best_estimator_

brf_grid = {
                'min_samples_split': np.arange(1,5,1),

            }
best_brf = hypertune_fit_eval(brf, brf_grid)
plot_grid_search_validation_curve(best_brf, 'min_samples_split', title='BalancedRandomFore
```

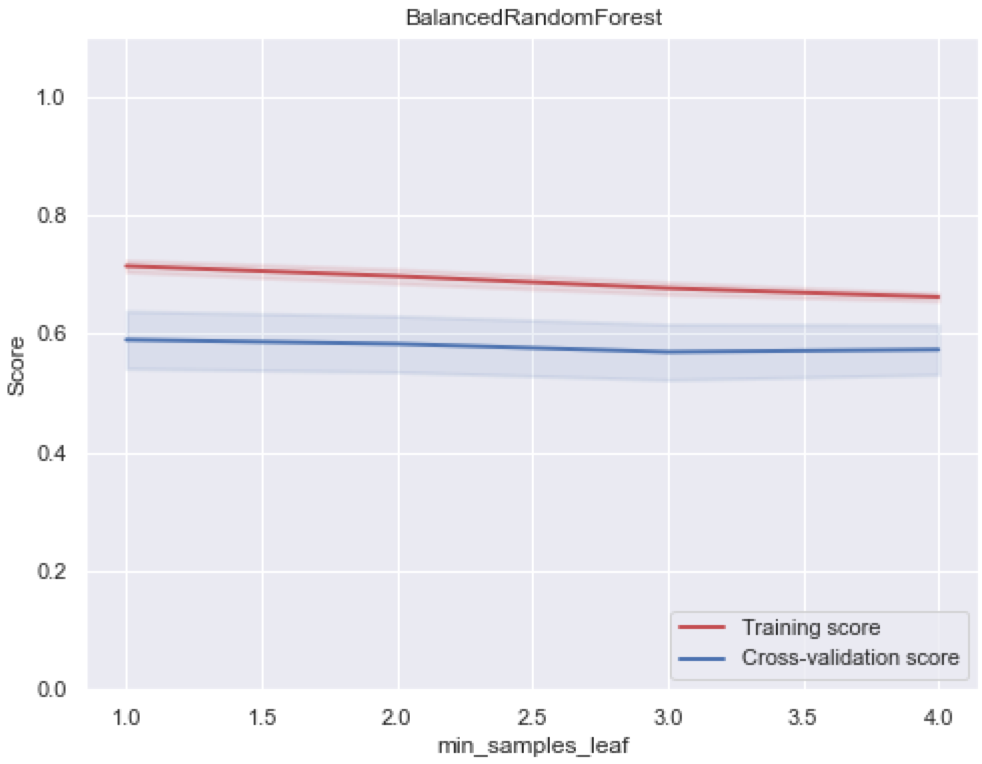
```
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_selection/_valid
ation.py:378: FitFailedWarning:
5 fits failed out of a total of 20.
The score on these train-test partitions for these parameters will be set to nan.
If these failures are not expected, you can try to debug them by setting error_score='rais
e'.

Below are more details about the failures:
--------------------------------------------------------------------------------
5 fits failed with the following error:
Traceback (most recent call last):
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_selectio
n/_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/imblearn/ensemble/_for
est.py", line 547, in fit
    samplers_trees = Parallel(
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/joblib/parallel.py", l
ine 1056, in __call__
    self.retrieve()
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/joblib/parallel.py", l
ine 935, in retrieve
    self._output.extend(job.get(timeout=self.timeout))
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/multiprocessing/pool.py", line 771,
in get
    raise self._value
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/multiprocessing/pool.py", line 125,
in worker
    result = (True, func(*args, **kwds))
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/joblib/_parallel_backe
nds.py", line 595, in __call__
    return self.func(*args, **kwargs)
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/joblib/parallel.py", l
ine 262, in __call__
    return [func(*args, **kwargs)
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/joblib/parallel.py", l
ine 262, in <listcomp>
    return [func(*args, **kwargs)
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/imblearn/ensemble/_for
est.py", line 61, in _local_parallel_build_trees
    tree = _parallel_build_trees(
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/ensemble/_fore
st.py", line 189, in _parallel_build_trees
    tree.fit(X, y, sample_weight=curr_sample_weight, check_input=False)
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/tree/_classes.
py", line 969, in fit
    super().fit(
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/tree/_classes.
py", line 265, in fit
    check_scalar(
  File "/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/utils/validati
on.py", line 1480, in check_scalar
    raise ValueError(
ValueError: min_samples_split == 1, must be >= 2.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_selection/_searc
h.py:953: UserWarning: One or more of the test scores are non-finite: [       nan 0.590015
74 0.57822054 0.58156182]
  warnings.warn(
/Users/minghuizhu/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_selection/_searc
h.py:953: UserWarning: One or more of the train scores are non-finite: [       nan 0.71436
58  0.70451168 0.70526346]
  warnings.warn(
 The best estimator:
 BalancedRandomForestClassifier(max_depth=9, n_estimators=500, n_jobs=-1,
                               random_state=42)

 The best score:
 0.5900157351880037

 The best parameters:
 {'min_samples_split': 2}

 Train Time:
 4.845700025558472
<class 'pandas.core.frame.DataFrame'>
```



In [68]:

```
# brf

# random forest
brf = best_brf.best_estimator_

brf_grid = {
                'min_samples_leaf': np.arange(1, 5, 1)
            }
best_brf = hypertune_fit_eval(brf, brf_grid)
plot_grid_search_validation_curve(best_brf, 'min_samples_leaf', title='BalancedRandomFores
```

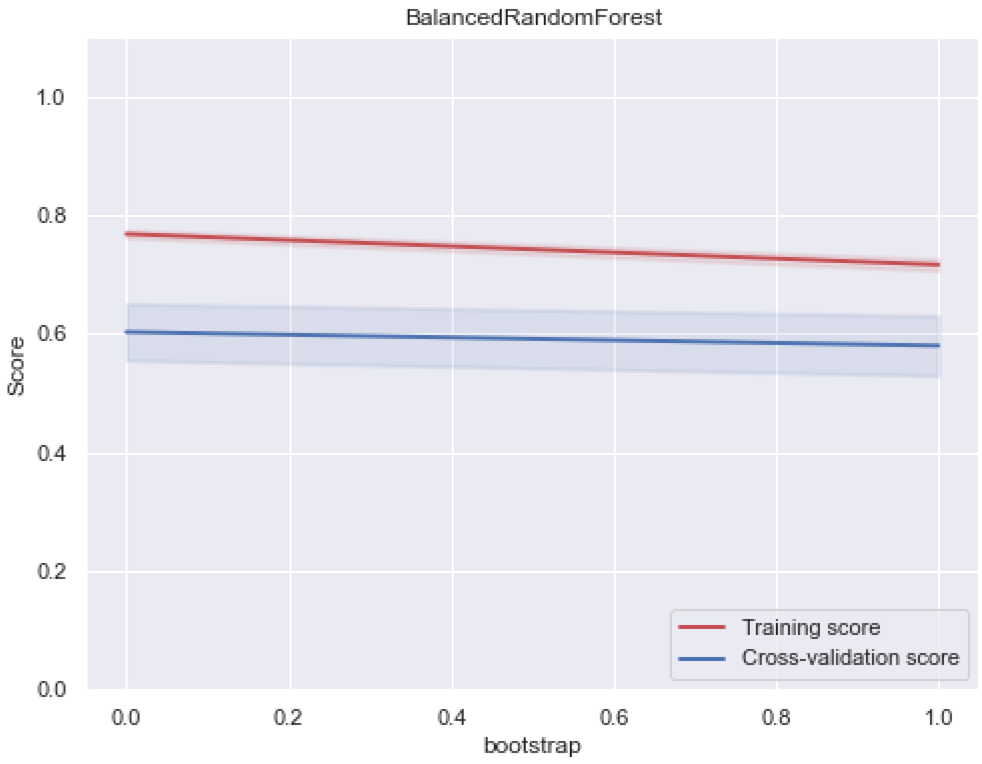
```
 The best estimator:
 BalancedRandomForestClassifier(max_depth=9, n_estimators=500, n_jobs=-1,
                                random_state=42)

 The best score:
 0.5900157351880037

 The best parameters:
 {'min_samples_leaf': 1}

 Train Time:
 6.5085930824279785
<class 'pandas.core.frame.DataFrame'>
```



In [70]:

```
# brf

# random forest
brf = best_brf.best_estimator_

brf_grid = {
               'bootstrap': [True, False]
           }
best_brf = hypertune_fit_eval(brf, brf_grid)
plot_grid_search_validation_curve(best_brf, 'bootstrap', title='BalancedRandomForest')
```

```
 The best estimator:
 BalancedRandomForestClassifier(bootstrap=False, max_depth=11, n_estimators=900,
                               n_jobs=-1, random_state=42)

 The best score:
 0.6028438503260122

 The best parameters:
 {'bootstrap': False}

 Train Time:
 6.63654088973999
<class 'pandas.core.frame.DataFrame'>
```



In [240…

```
# gbc
gbc = GradientBoostingClassifier(random_state = 42)
gbc_grid = {
    "n_estimators":np.arange(50, 500, 50),
    "max_depth":[1,3,5,7,9,11,13],
    "learning_rate":np.arange(0.01, 0.3, 0.01),
#      'colsample_bytree': np.arange(0.6, 1.0, 0.1),
#      'colsample_bylevel': np.arange(0.6, 1.0, 0.1),
    'subsample': np.arange(0.6, 1.0, 0.1),
}
best_gbc = hypertune_fit_eval(gbc, gbc_grid)
```

```
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
/var/folders/xq/07znzf8d6vd8p3m419_d9rv00000gn/T/ipykernel_1427/3124940627.py in <module>
      9     'subsample': np.arange(0.6, 1.0, 0.1),
     10 }
---> 11 best_gbc = hypertune_fit_eval(gbc, gbc_grid)

/var/folders/xq/07znzf8d6vd8p3m419_d9rv00000gn/T/ipykernel_1427/1032408374.py in hypertune
_fit_eval(estimator, param_grid)
      5                             cv = StratifiedKFold(), verbose=0, n_jobs = -1, scor
ing = "f1", refit = "f1")
      6     start = time.time()
----> 7     grid_obj.fit(X, y)
      8     end = time.time()
      9 

~/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_selection/_search.py in fit(sel
f, X, y, groups, **fit_params)
    873             return results
    874 
--> 875         self._run_search(evaluate_candidates)
    876 
    877         # multimetric is determined here because in the case of a callable

~/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_selection/_search.py in _run_sea
rch(self, evaluate_candidates)
   1377     def _run_search(self, evaluate_candidates):
```

```
   1378         """Search all candidates in param_grid"""
-> 1379         evaluate_candidates(ParameterGrid(self.param_grid))
   1380 
   1381 

~/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_selection/_search.py in evaluate
_candidates(candidate_params, cv, more_results)
    820                     )
    821 
--> 822                 out = parallel(
    823                     delayed(_fit_and_score)(
    824                         clone(base_estimator),

~/opt/anaconda3/lib/python3.9/site-packages/joblib/parallel.py in __call__(self, iterable)
   1054 
   1055             with self._backend.retrieval_context():
-> 1056                 self.retrieve()
   1057             # Make sure that we get a last message telling us we are done
   1058             elapsed_time = time.time() - self._start_time

~/opt/anaconda3/lib/python3.9/site-packages/joblib/parallel.py in retrieve(self)
    933             try:
    934                 if getattr(self._backend, 'supports_timeout', False):
--> 935                     self._output.extend(job.get(timeout=self.timeout))
    936                 else:
    937                     self._output.extend(job.get())

~/opt/anaconda3/lib/python3.9/site-packages/joblib/_parallel_backends.py in wrap_future_re
sult(future, timeout)
    540         AsyncResults.get from multiprocessing."""
    541         try:
--> 542             return future.result(timeout=timeout)
    543         except CfTimeoutError as e:
    544             raise TimeoutError from e

~/opt/anaconda3/lib/python3.9/concurrent/futures/_base.py in result(self, timeout)
    438                     return self.__get_result()
    439 
--> 440                 self._condition.wait(timeout)
    441 
    442                 if self._state in [CANCELLED, CANCELLED_AND_NOTIFIED]:

~/opt/anaconda3/lib/python3.9/threading.py in wait(self, timeout)
    310         try:    # restore state no matter what (e.g., KeyboardInterrupt)
    311             if timeout is None:
--> 312                 waiter.acquire()
    313                 gotit = True
    314             else:

KeyboardInterrupt: 
```

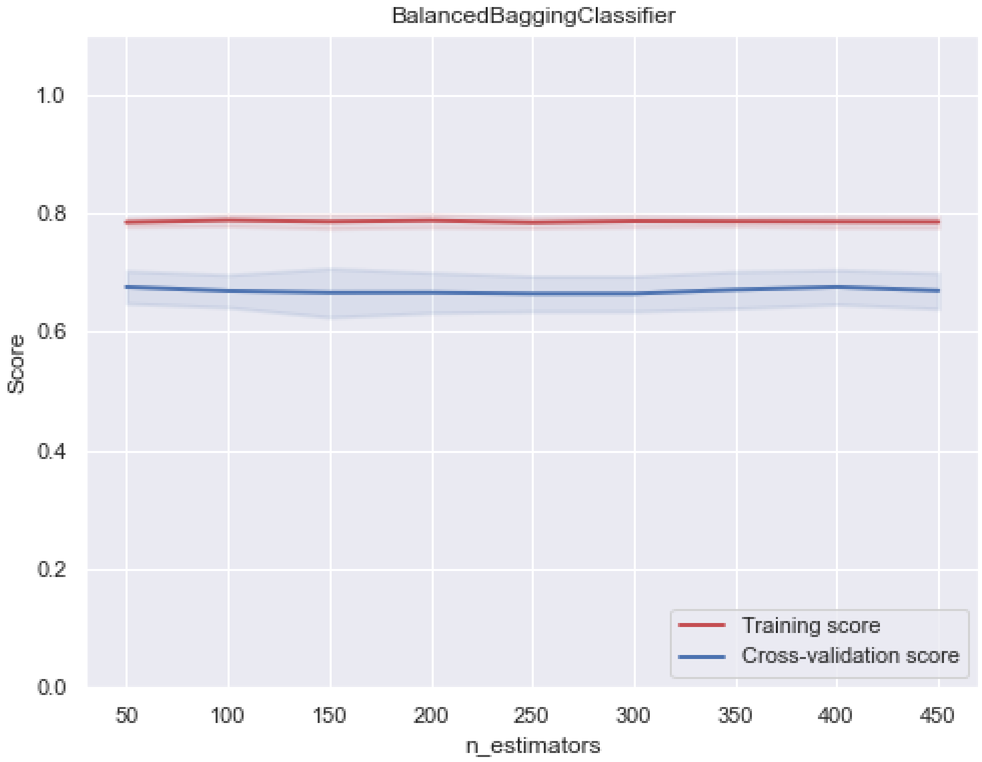
In [ ]:

```
# xgb
xgboost = XGBClassifier()
# Define the search space
param_grid = {
    # Learning rate shrinks the weights to make the boosting process more conservative
#     "learning_rate": [0.0001,0.001, 0.01, 0.1, 1] ,
    # Maximum depth of the tree, increasing it increases the model complexity.
#     "max_depth": range(3,21,3),
    # Gamma specifies the minimum loss reduction required to make a split.
    "gamma": [i/10.0 for i in range(0,5)],
    # Percentage of columns to be randomly samples for each tree.
    "colsample_bytree": [i/10.0 for i in range(3,10)],
    # reg_alpha provides l1 regularization to the weight, higher values result in more co
    "reg_alpha": [1e-5, 1e-2, 0.1, 1, 10, 100],
    # reg_lambda provides l2 regularization to the weight, higher values result in more co
    "reg_lambda": [1e-5, 1e-2, 0.1, 1, 10, 100],

}


xgb_model_tuned = hypertune_fit_eval(xgboost, param_grid)
```

In [71]:

```
bbc = BalancedBaggingClassifier(base_estimator=HistGradientBoostingClassifier(random_state
        n_jobs=-1)

bbc_grid = {
    "n_estimators":np.arange(50, 500, 50),
#     "max_depth":[1,3,5,7,9,11,13],
#     "learning_rate":np.arange(0.01, 0.3, 0.01),
#     'colsample_bytree': np.arange(0.6, 1.0, 0.1),
#     'colsample_bylevel': np.arange(0.6, 1.0, 0.1),
#     'subsample': np.arange(0.6, 1.0, 0.1),
}

best_bbc = hypertune_fit_eval(bbc, bbc_grid)
plot_grid_search_validation_curve(best_bbc, 'n_estimators', title='BalancedBaggingClassifi
```

```
 The best estimator:
 BalancedBaggingClassifier(base_estimator=HistGradientBoostingClassifier(random_state=42),
                           n_estimators=400, n_jobs=-1, random_state=42)

 The best score:
 0.6757341052521776

 The best parameters:
 {'n_estimators': 400}

 Train Time:
 311.64144587516785
<class 'pandas.core.frame.DataFrame'>
```

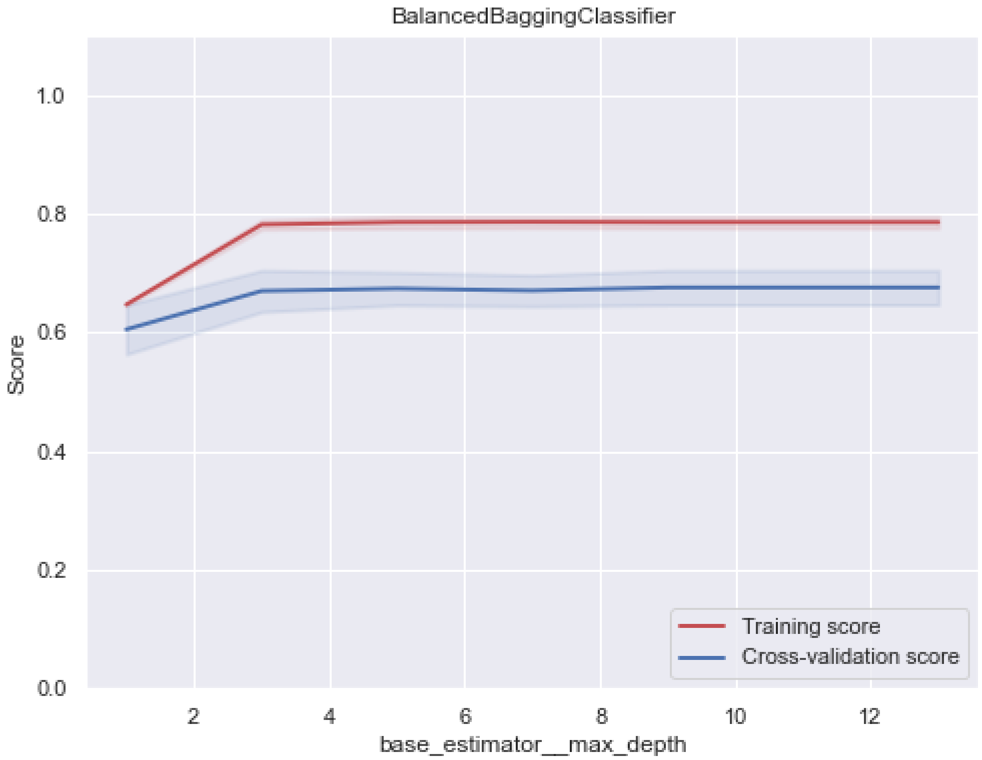


In [76]:

```
bbc = best_bbc.best_estimator_
```

```
bbc_grid = {
    'base_estimator__max_depth': [1,3,5,7,9,11,13]
#     "learning_rate":np.arange(0.01, 0.3, 0.01),
#     'colsample_bytree': np.arange(0.6, 1.0, 0.1),
#     'colsample_bylevel': np.arange(0.6, 1.0, 0.1),
#     'subsample': np.arange(0.6, 1.0, 0.1),
}

best_bbc = hypertune_fit_eval(bbc, bbc_grid)
plot_grid_search_validation_curve(best_bbc,  'base_estimator__max_depth', title='BalancedB
```

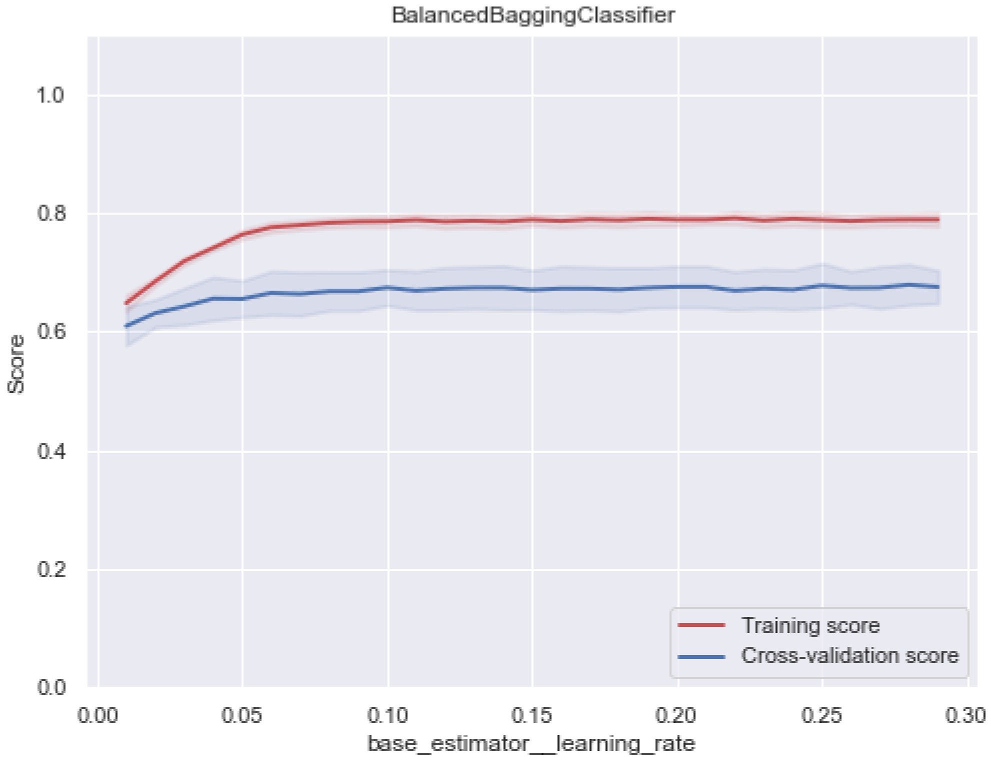
```
 The best estimator:
 BalancedBaggingClassifier(base_estimator=HistGradientBoostingClassifier(max_depth=9,
                                                                        random_state=42),
                          n_estimators=400, n_jobs=-1, random_state=42)

 The best score:
 0.6757341052521776

 The best parameters:
 {'base_estimator__max_depth': 9}

 Train Time:
 353.4232859611511
<class 'pandas.core.frame.DataFrame'>
```



In [116…

```
bbc = best_bbc.best_estimator_

bbc_grid = {
     "base_estimator__learning_rate":np.arange(0.01, 0.3, 0.01),
}

best_bbc = hypertune_fit_eval(bbc, bbc_grid)
plot_grid_search_validation_curve(best_bbc,  'base_estimator__learning_rate', title='Balar
```

```
 The best estimator:
 BalancedBaggingClassifier(base_estimator=HistGradientBoostingClassifier(learning_rate=0.2
8,
                                                                        max_depth=9,
                                                                        random_state=42),
                                                       n_estimators=400, n_jobs=-1, random_state=42)

 The best score:
 0.6790538188912173

 The best parameters:
 {'base_estimator__learning_rate': 0.28}

 Train Time:
 1648.3858020305634
<class 'pandas.core.frame.DataFrame'>
```



In [334…

```python
# adaboost
ada = AdaBoostClassifier(random_state = 42)
ada_grid = {
    "n_estimators": [int(i) for i in np.linspace(1, 100, num = 20)],
    "learning_rate": [0.01,0.05,0.1,0.2,0.4,0.5,1],
    "algorithm": ['SAMME', 'SAMME.R']
}
best_ada = hypertune_fit_eval(ada, ada_grid)
```

```
The best estimator:
AdaBoostClassifier(learning_rate=0.5, n_estimators=84, random_state=42)

The best score:
0.7151626111324687

The best parameters:
{'algorithm': 'SAMME.R', 'learning_rate': 0.5, 'n_estimators': 84}

Train Time:
20.870769739151
```

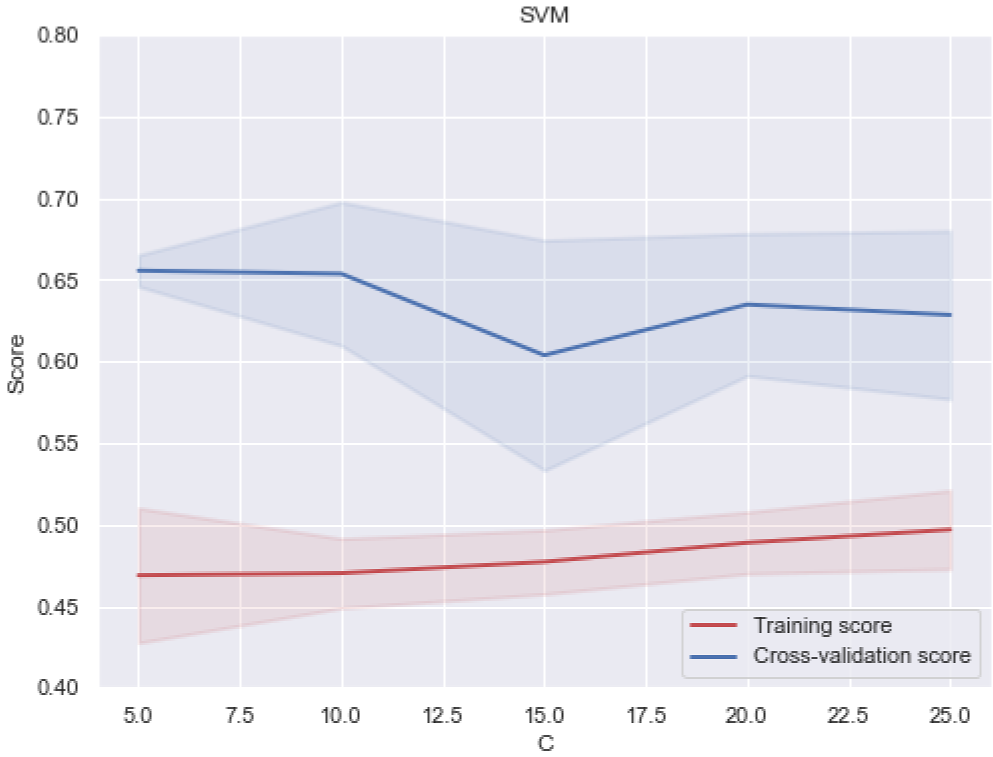
In [ ]:

```python
# easy ensemble

eec = EasyEnsembleClassifier(random_state=42, n_jobs=-1, verbose = 1, base_estimator = Gra
eec_grid = {
    "n_estimators": [int(i) for i in np.linspace(1, 100, num = 20)],
#     "learning_rate": [0.01,0.05,0.1,0.2,0.4,0.5,1,5,10,15,20,30,40,50,60,70,80,90,100],
    "sampling_strategy": ['float', 'str', 'dict', 'callable', 'auto']
}
best_eec = hypertune_fit_eval(eec, eec_grid)
```

In [138…

```
# svm
svm = SVC(random_state=42, kernel="sigmoid")
svm_grid = {
    'C': np.arange(5,30,5)
#     "gamma": [0.0001, 0.001, 0.01, 0.1, 1, 10, 100],
#     param_grid = {'C': [0.1,1, 10, 100], 'gamma': [1,0.1,0.01,0.001],'kernel': ['rbf',
}

best_svm = hypertune_fit_eval(svm, svm_grid)
plot_grid_search_validation_curve(best_svm, 'C', title='SVM', ylim=[0.4,0.8])
```

```
 The best estimator:
 SVC(C=5, kernel='sigmoid', random_state=42)

 The best score:
 0.6556402737047898

 The best parameters:
 {'C': 5}

 Train Time:
 0.20191526412963867
<class 'pandas.core.frame.DataFrame'>
```

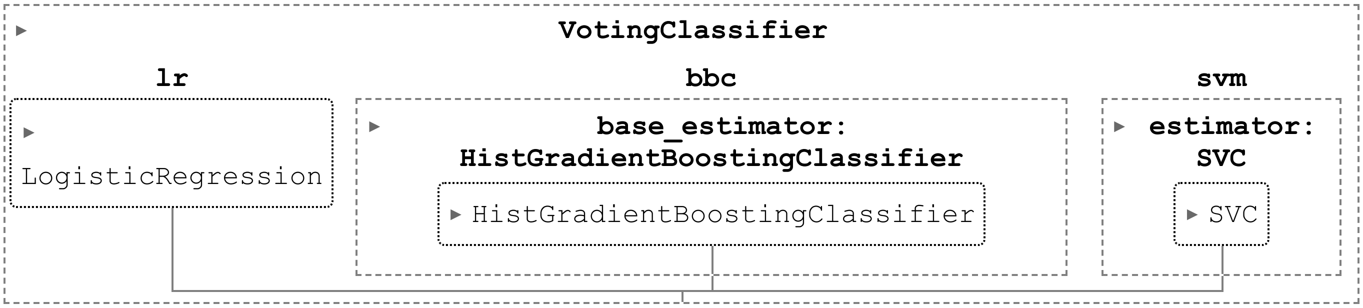


In [159…

```
# try using voting methods
from sklearn.ensemble import VotingClassifier
from sklearn.ensemble import StackingClassifier
vo = [
    ("lr", best_lr.best_estimator_),
    ("bbc", best_bbc.best_estimator_),
    ("svm", best_svm_smote)]


clf = VotingClassifier(estimators=vo)
```

```
clf.fit(X,y)
```

Out[159…



▶ VotingClassifier

lr

▶ LogisticRegression

bbc

▶ base_estimator: HistGradientBoostingClassifier

▶ HistGradientBoostingClassifier

svm

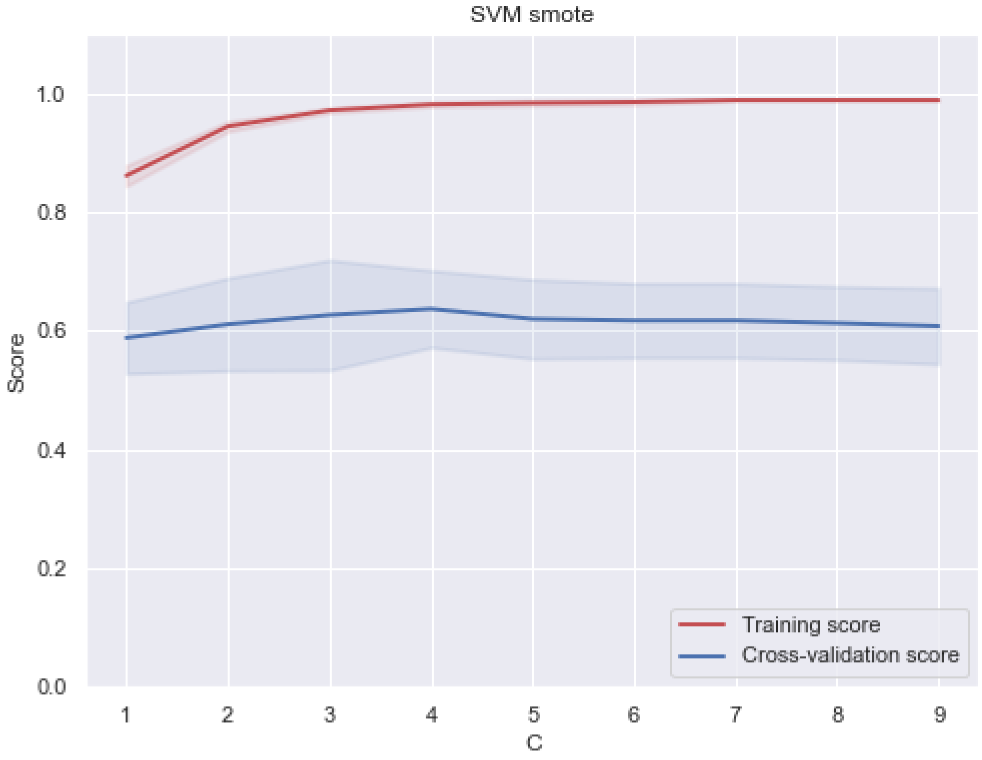
▶ estimator: SVC

▶ SVC

In [141…

```
# svm
svm = SVC(random_state=42, kernel="rbf")
svm_grid = {
#     "gamma": [0.0001, 0.001, 0.01, 0.1, 1, 10, 100],
    'C': np.arange(1,10,1)
#     param_grid = {'C': [0.1,1, 10, 100], 'gamma': [1,0.1,0.01,0.001],'kernel': ['rbf',
}

best_svm_smote = hypertune_fit_eval(svm, svm_grid)
plot_grid_search_validation_curve(best_svm_smote, 'C', title='SVM smote')
```

```
The best estimator:
SVC(C=4, random_state=42)

The best score:
0.6369620575502928

The best parameters:
{'C': 4}

Train Time:
0.8349130153656006
<class 'pandas.core.frame.DataFrame'>
```

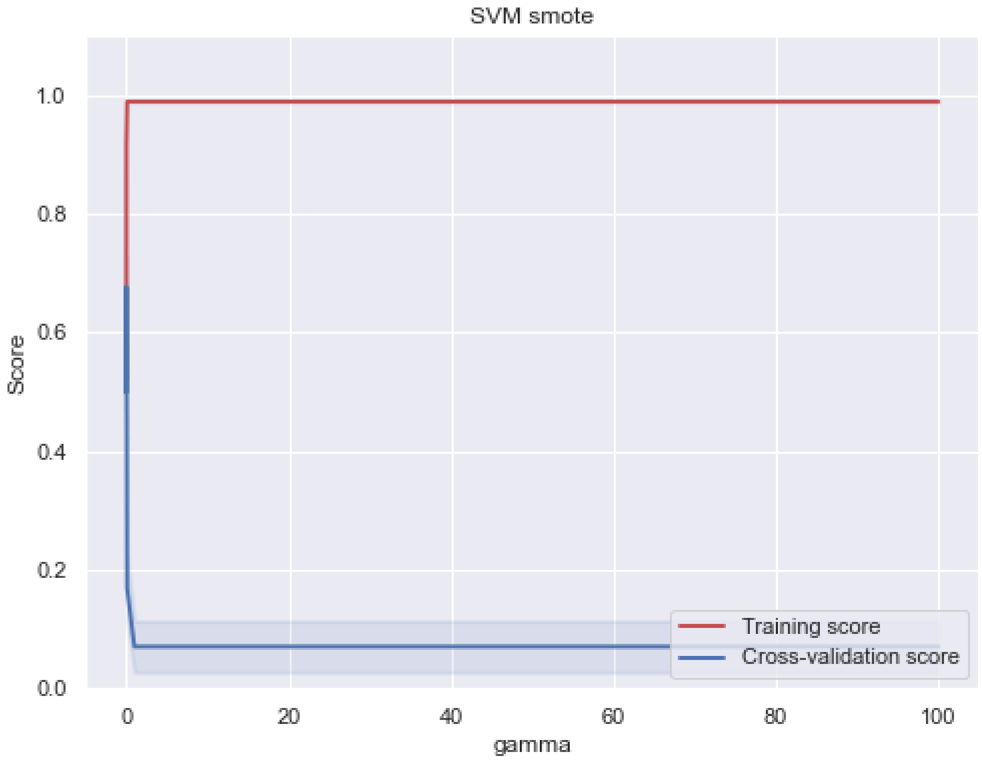


In [155…

```
# svm
```

```
svm = SVC(random_state=42, kernel="rbf", C=4)
svm_grid = {
    "gamma": [0.0001, 0.001, 0.01, 0.1, 1, 10, 100]
}

best_svm_smote = hypertune_fit_eval(svm, svm_grid)
plot_grid_search_validation_curve(best_svm_smote, 'gamma', title='SVM smote')
```

```
The best estimator:
SVC(C=4, gamma=0.01, random_state=42)

The best score:
0.6770558608058608

The best parameters:
{'gamma': 0.01}

Train Time:
1.5110981464385986
<class 'pandas.core.frame.DataFrame'>
```



In [74]:

```
def create_submission(grid, output='my_submission.csv'):
    clf = grid.best_estimator_
    # define the submission file
    submission_result = pd.DataFrame()
    # load test_data
    X_submission = test_data
#     X_submission = test_data.drop(dict_for_feature_select_list, axis=1)
    # apply standardscaler fitted earlier
    X_submission = scale.transform(X_submission)
    y_submission = clf.predict(X_submission)
    # record the prediction
    submission_result['Id'] = sample_submission_data['Id']
    submission_result['Predicted'] = y_submission
    # save submission
    submission_result.to_csv(output, index = False)
```

In [454…

```
def create_submission_nondrop(grid, output='my_submission.csv'):
    clf = grid.best_estimator_
    # define the submission file
    submission_result = pd.DataFrame()
    # load test_data
#     X_submission = test_data
    X_submission = test_data
    # apply standardscaler fitted earlier
    X_submission = scale.transform(X_submission)
    y_submission = clf.predict(X_submission)
    # record the prediction
    submission_result['Id'] = sample_submission_data['Id']
    submission_result['Predicted'] = y_submission
    # save submission
    submission_result.to_csv(output, index = False)
```

In [ ]:

```
# rf
create_submission(rf_model_tuned, output='XAJI0Y6DPB.csv')
```

In [ ]:

```
# xgb
create_submission(xgb_model_tuned, output='HSAHXTHV3A.csv')
```

In [115…

```
# lg
create_submission(best_lr, output='best_lr.csv')
```

In [539…

```
# lg nondrop
create_submission(best_lr, output='XXXXXXXX.csv')
```

In [ ]:

```
# gbc
create_submission(best_model_gbc, output='H75LXO6QJI.csv')
```

In [335…

```
# ada
create_submission(best_ada, output='31Y2R2FLJV.csv')
```

In [ ]:

```
# eec
create_submission(best_eec, output='0Y9DOM5IGQ.csv')
```

In [110…

```
# rus
create_submission(best_rus, output='RFZ7JM85VS.csv')
```

In [276…

```
# svm
create_submission(best_svm, output='DEQU0ZEYV9.csv')
```

In [332…

```
# svm smote
create_submission(best_svm_smote, output='WMN25BIKYZ.csv')
```

In [77]:

```
# brf
create_submission(best_brf, output='best_brf.csv')
```

In [117…

```
# bbc
create_submission(best_bbc, output='best_bbc.csv')
```

In [158…

```
def create_submission_voting(clf, output='my_submission.csv'):
    clf = clf
    # define the submission file
    submission_result = pd.DataFrame()
    # load test_data
    X_submission = test_data
    X_submission = scale.transform(X_submission)
    y_submission = clf.predict(X_submission)
    # record the prediction
    submission_result['Id'] = sample_submission_data['Id']
    submission_result['Predicted'] = y_submission
    # save submission
    submission_result.to_csv(output, index = False)

# bbc
create_submission_voting(clf, output='best_vog.csv')
```