HW2 Q2

February 4, 2024

In this notebook, we do the same classifier explorations and strategy comparisons as the previous notebook. However in this case we optimize for the features and the hyperparameters using a new objective function which uses a new definition of profit.

Here the definition of profit will use the predict_proba method from the classifiers on the validation set, from which we can obtain the conviction for each prediction:

$$\text{conviction}_s = \text{Prob}_s(+1) - \text{Prob}_s(-1)$$

Then

$$\text{weights} = \frac{\text{conviction}_s}{\sum_{s'} |conviction_{s'}|}$$

So

$$\sum_s \text{weights} = 1$$

The profit is then

$$\sum_s \text{weights} * \text{'next\_period\_return'}$$

```python
[1]: import pandas as pd
     import numpy as np
     import matplotlib.pyplot as plt
     %matplotlib inline
     from sklearn.metrics import accuracy_score, confusion_matrix
     from sklearn.tree import DecisionTreeClassifier
     from sklearn.ensemble import BaggingClassifier
     from sklearn.ensemble import RandomForestClassifier
     import sklearn
     from sklearn.preprocessing import StandardScaler

     pd.set_option('use_inf_as_na', True)
     from collections import Counter

     from tqdm import tqdm # to measure progress of for loops
```

```
/var/folders/sp/wlr6xm2979l8vx6kjh2z1dk00000gn/T/ipykernel_1879/524871555.py:12:
FutureWarning: use_inf_as_na option is deprecated and will be removed in a
future version. Convert inf values to NaN before operating instead.
  pd.set_option('use_inf_as_na', True)
```

```
[2]: # load dataset
     raw_data = pd.read_pickle('dataset.pkl')
     data = raw_data.drop([x  for x in raw_data.columns if 'fqtr' in x],axis=1)
     # restrict companies to market cap > 1 billion
     data = raw_data[raw_data['market_cap'] > 1000.0]
     data = data.copy()
     # fill in missing values
     data.fillna(0.0,inplace=True)
```

0.0.1 Insert a column in dataset based on stock performance

Inserting a column in the dataset where entries are:
- 1 if the stock return is more than 5% higher than the SPY return
- 0 if it is between -10% and +5% relative to the SPY return
- -1 if it is less then -10% relative to the SPY return

```
[3]: # function to return appropriate values based on performance as detailed above
     def f(x):
         if x > 0.05:
             return 1
         elif x < -0.1:
             return -1
         else:
             return 0
```

```
[4]: # add the new column
     data['rel_performance'] = data['pred_rel_return'].apply(f)
     # make the date the index
     data.reset_index(inplace=True)
     data.set_index('date',inplace=True)
```

```
[5]: data[['pred_rel_return', 'rel_performance']][100:110]
```

```
[5]:             pred_rel_return  rel_performance
     date
     2000-04-03         0.261336                1
     2000-04-05        -0.337466               -1
     2000-04-06         0.272372                1
     2000-04-07        -0.645219               -1
     2000-04-07         0.192161                1
     2000-04-11         0.153474                1
     2000-04-11         0.317203                1
     2000-04-11        -0.051039                0
     2000-04-11         0.028730                0
     2000-04-11         0.095712                1
```

0.0.2 Split the data into training, validation, and test

- Data for training period is from 2007 to 2009 (inclusive, i.e. 3 years)
- Data for validation period is 1 quarter after end of training period
- Data for test period is immediately proceeding the training period

```python
[6]: df_1 = data.loc['2007-01-01':'2010-01-01']
     df_valid = data.loc['2010-04-01':'2010-07-01']
     df_test = data.loc['2010-07-01':'2010-10-01']
```

```python
[7]: train_1 = df_1.reset_index().drop(['ticker','date',
                                        'next_period_return',
                                        'spy_next_period_return',
                                        'rel_performance','pred_rel_return',
                                        'return', 'cum_ret', 'spy_cum_ret'],axis=1)

     valid = df_valid.reset_index().drop(['ticker','date',
                                          'next_period_return',
                                          'spy_next_period_return',
                                          'rel_performance','pred_rel_return',
                                          'return', 'cum_ret', 'spy_cum_ret'],axis=1)

     test = df_test.reset_index().drop(['ticker','date',
                                        'next_period_return',
                                        'spy_next_period_return',
                                        'rel_performance','pred_rel_return',
                                        'return', 'cum_ret', 'spy_cum_ret'],axis=1)
```

```python
[8]: # Obtain the y values for each data split
     train_1_stock_returns = df_1['next_period_return']
     valid_stock_returns = df_valid['next_period_return']
     test_stock_returns = df_test['next_period_return']

     y_1 = df_1['rel_performance']
     y_valid = df_valid['rel_performance']
     y_test = df_test['rel_performance']

     y_1 = y_1.values
     y_valid = y_valid.values
     y_test = y_test.values
```

0.0.3 Import Optuna to find the optimal hyperparameters for the classifiers

```python
[9]: import optuna
     from optuna.trial import Trial
     # optuna.logging.set_verbosity(optuna.logging.FATAL)
     import warnings
     warnings.filterwarnings("ignore")
```

0.1 Defining the Optuna objective function for our 3 classifiers:

- DecisionTree classifier
- Bagging classifier
- RandomForest classifier

0.1.1 Note now that we are optimizng for the new definitoin of the profit using the 'conviction' of the model.

```python
[10]: def objective_tree(trial:
      ↪Trial,train=None,labels=None,val=None,val_labels=None,val_rets=None):

          t_min_samples_leaf = trial.suggest_int('min_samples_leaf',100,1200,step=200)
          t_max_depth = trial.suggest_int('max_depth',5,25,step=5)

          t_clf = DecisionTreeClassifier(min_samples_leaf =␣
      ↪t_min_samples_leaf,max_depth=t_max_depth,random_state=123)
          t_clf.fit(train,labels)

          # Predicting probabilities
          probs = t_clf.predict_proba(val)

          # Conviction for each stock
          conviction = probs[:, 2] - probs[:, 0]   # Prob_s(+1) - Prob_s(-1)
          weights = conviction / np.sum(np.abs(conviction))

          # Calculating profit
          profit = np.sum(weights * val_rets)

          return profit
```

```python
[11]: def objective_bagging(trial:
      ↪Trial,train=None,labels=None,val=None,val_labels=None,val_rets=None):

          t_min_samples_leaf = trial.suggest_int('min_samples_leaf',100,1200,step=200)
          t_max_depth = trial.suggest_int('max_depth',5,25,step=5)
          t_n_estimators = trial.suggest_int('n_estimators',5,50,step=5)

          tree_clf = DecisionTreeClassifier(min_samples_leaf =␣
      ↪t_min_samples_leaf,max_depth=t_max_depth,random_state=123)
          bg_clf =␣
      ↪BaggingClassifier(tree_clf,n_estimators=t_n_estimators,random_state=123,n_jobs=1)
          bg_clf.fit(train,labels)

          # Predicting probabilities
          probs = bg_clf.predict_proba(val)

          # Conviction for each stock
```

```python
        conviction = probs[:, 2] - probs[:, 0]    # Prob_s(+1) - Prob_s(-1)
        weights = conviction / np.sum(np.abs(conviction))

        # Calculating profit
        profit = np.sum(weights * val_rets)

        return profit
```

```python
[12]: def objective_rf(trial:
    ↪Trial,train=None,labels=None,val=None,val_labels=None,val_rets=None):

        rf_n_estimators = trial.suggest_int('n_estimators', 10,40,step=5)
        rf_max_features = trial.suggest_categorical('max_features',['sqrt','log2'])
        rf_min_samples_leaf = trial.
    ↪suggest_int('min_samples_leaf',800,2400,step=800)
        rf_max_depth = trial.suggest_int('max_depth',4,15)

        rf_clf = RandomForestClassifier(n_estimators=rf_n_estimators,
                                        max_depth=rf_max_depth,
                                        min_samples_leaf=rf_min_samples_leaf,
                                        ⊔
    ↪max_features=rf_max_features,random_state=123)
        rf_clf.fit(train,labels)

        # Predicting probabilities
        probs = rf_clf.predict_proba(val)

        # Conviction for each stock
        conviction = probs[:, 2] - probs[:, 0]    # Prob_s(+1) - Prob_s(-1)
        weights = conviction / np.sum(np.abs(conviction))

        # Calculating profit
        profit = np.sum(weights * val_rets)

        return profit
```

```python
[13]: study_tree = optuna.create_study(direction="maximize")
      study_bagging = optuna.create_study(direction="maximize")
      study_rf = optuna.create_study(direction="maximize")
```

```
[I 2024-02-04 19:49:52,271] A new study created in memory with name: no-
name-99061f9f-bc79-4399-8d59-724c220fdb93
[I 2024-02-04 19:49:52,272] A new study created in memory with name: no-
name-2d115b25-6ec6-42d9-bca8-59743d956cf0
[I 2024-02-04 19:49:52,272] A new study created in memory with name: no-
name-43cb0cbd-7ad8-4643-b14c-cc6f7228ffe3
```

0.1.2 Run optimizations to find optimal parameters

```
[14]: from functools import partial
```

```
[15]: %%time
study_tree.
   ↪optimize(partial(objective_tree,train=train_1,labels=y_1,val=valid,val_labels=y_valid,val_r
   ↪n_trials=200,n_jobs=-1)
```

```
[I 2024-02-04 19:49:53,297] Trial 9 finished with value: -0.03507104894488454
and parameters: {'min_samples_leaf': 1100, 'max_depth': 25}. Best is trial 9
with value: -0.03507104894488454.
[I 2024-02-04 19:49:53,496] Trial 8 finished with value: -0.03507104894488454
and parameters: {'min_samples_leaf': 1100, 'max_depth': 15}. Best is trial 9
with value: -0.03507104894488454.
[I 2024-02-04 19:49:53,603] Trial 0 finished with value: -0.03170653629246879
and parameters: {'min_samples_leaf': 700, 'max_depth': 15}. Best is trial 0 with
value: -0.03170653629246879.
[I 2024-02-04 19:49:53,609] Trial 6 finished with value: -0.03507104894488454
and parameters: {'min_samples_leaf': 1100, 'max_depth': 10}. Best is trial 0
with value: -0.03170653629246879.
[I 2024-02-04 19:49:53,676] Trial 1 finished with value: -0.03618642324470992
and parameters: {'min_samples_leaf': 900, 'max_depth': 25}. Best is trial 0 with
value: -0.03170653629246879.
[I 2024-02-04 19:49:53,679] Trial 2 finished with value: -0.030271772656712496
and parameters: {'min_samples_leaf': 500, 'max_depth': 15}. Best is trial 2 with
value: -0.030271772656712496.
[I 2024-02-04 19:49:53,759] Trial 5 finished with value: -0.034943347794546935
and parameters: {'min_samples_leaf': 300, 'max_depth': 5}. Best is trial 2 with
value: -0.030271772656712496.
[I 2024-02-04 19:49:53,818] Trial 4 finished with value: -0.030271772656712496
and parameters: {'min_samples_leaf': 500, 'max_depth': 20}. Best is trial 2 with
value: -0.030271772656712496.
[I 2024-02-04 19:49:53,930] Trial 7 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 10}. Best is trial 2 with
value: -0.030271772656712496.
[I 2024-02-04 19:49:54,488] Trial 3 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 3 with
value: -0.02944046269221485.
[I 2024-02-04 19:49:54,612] Trial 12 finished with value: -0.03507104894488454
and parameters: {'min_samples_leaf': 1100, 'max_depth': 25}. Best is trial 3
with value: -0.02944046269221485.
[I 2024-02-04 19:49:54,742] Trial 11 finished with value: -0.030271772656712496
and parameters: {'min_samples_leaf': 500, 'max_depth': 15}. Best is trial 3 with
value: -0.02944046269221485.
[I 2024-02-04 19:49:54,780] Trial 13 finished with value: -0.03507104894488454
and parameters: {'min_samples_leaf': 1100, 'max_depth': 5}. Best is trial 3 with
value: -0.02944046269221485.
```

[I 2024-02-04 19:49:54,901] Trial 15 finished with value: -0.03618642324470992 and parameters: {'min_samples_leaf': 900, 'max_depth': 20}. Best is trial 3 with value: -0.02944046269221485.
[I 2024-02-04 19:49:54,908] Trial 14 finished with value: -0.03170653629246879 and parameters: {'min_samples_leaf': 700, 'max_depth': 20}. Best is trial 3 with value: -0.02944046269221485.
[I 2024-02-04 19:49:55,042] Trial 17 finished with value: -0.030271772656712496 and parameters: {'min_samples_leaf': 500, 'max_depth': 25}. Best is trial 3 with value: -0.02944046269221485.
[I 2024-02-04 19:49:55,212] Trial 18 finished with value: -0.030271772656712496 and parameters: {'min_samples_leaf': 500, 'max_depth': 25}. Best is trial 3 with value: -0.02944046269221485.
[I 2024-02-04 19:49:55,299] Trial 16 finished with value: -0.033228938079633744 and parameters: {'min_samples_leaf': 300, 'max_depth': 20}. Best is trial 3 with value: -0.02944046269221485.
[I 2024-02-04 19:49:55,335] Trial 10 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:55,747] Trial 19 finished with value: -0.03587929079557034 and parameters: {'min_samples_leaf': 100, 'max_depth': 5}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:56,705] Trial 24 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:56,849] Trial 20 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:56,915] Trial 23 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:57,081] Trial 22 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:57,193] Trial 21 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:57,242] Trial 25 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:57,288] Trial 26 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:57,373] Trial 28 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:49:57,535] Trial 27 finished with value: -0.02944046269221485 and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10 with value: -0.029139837603797823.

```
[I 2024-02-04 19:49:57,982] Trial 29 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:58,385] Trial 35 finished with value: -0.034943347794546935
and parameters: {'min_samples_leaf': 300, 'max_depth': 5}. Best is trial 10 with
value: -0.029139837603797823.
[I 2024-02-04 19:49:58,488] Trial 34 finished with value: -0.034943347794546935
and parameters: {'min_samples_leaf': 300, 'max_depth': 5}. Best is trial 10 with
value: -0.029139837603797823.
[I 2024-02-04 19:49:58,553] Trial 30 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:58,678] Trial 37 finished with value: -0.034943347794546935
and parameters: {'min_samples_leaf': 300, 'max_depth': 5}. Best is trial 10 with
value: -0.029139837603797823.
[I 2024-02-04 19:49:58,722] Trial 33 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:58,749] Trial 36 finished with value: -0.034943347794546935
and parameters: {'min_samples_leaf': 300, 'max_depth': 5}. Best is trial 10 with
value: -0.029139837603797823.
[I 2024-02-04 19:49:59,018] Trial 31 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:59,046] Trial 32 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:59,118] Trial 38 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:59,526] Trial 39 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:59,812] Trial 40 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:49:59,962] Trial 42 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:00,004] Trial 41 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:00,238] Trial 48 finished with value: -0.03618642324470992
and parameters: {'min_samples_leaf': 900, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:00,257] Trial 43 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
```

```
[I 2024-02-04 19:50:00,353] Trial 44 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:00,574] Trial 47 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:00,709] Trial 46 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:00,911] Trial 49 finished with value: -0.03170653629246879
and parameters: {'min_samples_leaf': 700, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:00,996] Trial 45 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:01,881] Trial 51 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:01,882] Trial 50 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:02,339] Trial 53 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:02,427] Trial 54 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:02,439] Trial 52 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:02,606] Trial 55 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:02,818] Trial 56 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:02,872] Trial 58 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:03,073] Trial 57 finished with value: -0.02944046269221485
and parameters: {'min_samples_leaf': 100, 'max_depth': 10}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:03,246] Trial 59 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:03,743] Trial 60 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
```

```
[I 2024-02-04 19:50:03,806] Trial 61 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:04,244] Trial 68 finished with value: -0.03618642324470992
and parameters: {'min_samples_leaf': 900, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:04,503] Trial 69 finished with value: -0.03618642324470992
and parameters: {'min_samples_leaf': 900, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:04,585] Trial 62 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:05,020] Trial 67 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:05,064] Trial 63 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:05,083] Trial 64 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:05,273] Trial 66 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:05,306] Trial 65 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:05,689] Trial 70 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:05,873] Trial 71 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:06,137] Trial 72 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:06,723] Trial 77 finished with value: -0.030271772656712496
and parameters: {'min_samples_leaf': 500, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:06,793] Trial 78 finished with value: -0.030271772656712496
and parameters: {'min_samples_leaf': 500, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:06,839] Trial 79 finished with value: -0.030271772656712496
and parameters: {'min_samples_leaf': 500, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:06,846] Trial 74 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
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[I 2024-02-04 19:50:07,002] Trial 73 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:07,054] Trial 75 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:07,590] Trial 80 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:07,749] Trial 76 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:07,877] Trial 81 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:08,126] Trial 82 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:08,842] Trial 85 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:08,873] Trial 86 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:08,981] Trial 88 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:09,005] Trial 87 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:09,467] Trial 84 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:09,521] Trial 89 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:09,546] Trial 83 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:09,806] Trial 91 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:10,032] Trial 92 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:10,550] Trial 90 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
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[I 2024-02-04 19:50:10,770] Trial 94 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:10,800] Trial 93 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:10,899] Trial 98 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:10,937] Trial 95 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:10,986] Trial 96 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:11,383] Trial 99 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:11,738] Trial 100 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:12,015] Trial 97 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:12,194] Trial 104 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:12,242] Trial 101 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:12,418] Trial 107 finished with value: -0.033228938079633744
and parameters: {'min_samples_leaf': 300, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:12,650] Trial 103 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:12,863] Trial 105 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:13,146] Trial 106 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:13,293] Trial 102 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:13,905] Trial 109 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
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[I 2024-02-04 19:50:14,068] Trial 110 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:14,170] Trial 111 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:14,235] Trial 112 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:14,296] Trial 108 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:14,324] Trial 116 finished with value: -0.03170653629246879
and parameters: {'min_samples_leaf': 700, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:14,480] Trial 113 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:15,070] Trial 114 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:15,300] Trial 117 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:15,327] Trial 115 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:16,209] Trial 121 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:16,290] Trial 118 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:16,320] Trial 123 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:16,466] Trial 124 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:16,747] Trial 119 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:16,812] Trial 120 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:17,021] Trial 125 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.

[I 2024-02-04 19:50:17,495] Trial 127 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:17,636] Trial 126 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:17,765] Trial 122 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:18,351] Trial 128 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:18,459] Trial 129 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:18,466] Trial 131 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:18,492] Trial 130 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:18,775] Trial 133 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:18,825] Trial 132 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:19,077] Trial 134 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:19,481] Trial 140 finished with value: -0.03507104894488454 and parameters: {'min_samples_leaf': 1100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:19,521] Trial 135 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:19,711] Trial 142 finished with value: -0.03507104894488454 and parameters: {'min_samples_leaf': 1100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:19,772] Trial 136 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:19,780] Trial 143 finished with value: -0.03507104894488454 and parameters: {'min_samples_leaf': 1100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:19,990] Trial 144 finished with value: -0.03507104894488454 and parameters: {'min_samples_leaf': 1100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.

[I 2024-02-04 19:50:20,307] Trial 138 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:20,436] Trial 139 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:20,511] Trial 141 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:21,192] Trial 137 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:21,567] Trial 146 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:21,697] Trial 147 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:21,714] Trial 145 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:21,812] Trial 149 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:21,843] Trial 148 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:22,134] Trial 150 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:22,251] Trial 151 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:22,414] Trial 152 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:22,512] Trial 153 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:23,536] Trial 155 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:23,656] Trial 163 finished with value: -0.03170653629246879 and parameters: {'min_samples_leaf': 700, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.
[I 2024-02-04 19:50:23,764] Trial 157 finished with value: -0.029139837603797823 and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10 with value: -0.029139837603797823.

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[I 2024-02-04 19:50:23,840] Trial 156 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:23,897] Trial 158 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:24,044] Trial 154 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:24,075] Trial 159 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:24,216] Trial 160 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:24,294] Trial 161 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:24,415] Trial 162 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:25,679] Trial 165 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:25,778] Trial 167 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:25,838] Trial 164 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:25,906] Trial 166 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:26,068] Trial 168 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:26,190] Trial 170 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:26,207] Trial 171 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:26,293] Trial 172 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:26,602] Trial 173 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
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[I 2024-02-04 19:50:27,053] Trial 169 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:27,621] Trial 174 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:27,819] Trial 176 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:28,085] Trial 178 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:28,215] Trial 175 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:28,238] Trial 180 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:28,247] Trial 179 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:28,255] Trial 177 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:28,284] Trial 181 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:28,599] Trial 182 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:29,531] Trial 184 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:29,831] Trial 185 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:30,116] Trial 186 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:30,141] Trial 183 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:30,185] Trial 189 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:30,194] Trial 190 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.

```
[I 2024-02-04 19:50:30,248] Trial 188 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 15}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:30,303] Trial 187 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 20}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:30,433] Trial 191 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:30,598] Trial 192 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:31,405] Trial 193 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:31,701] Trial 194 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:31,909] Trial 195 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:31,971] Trial 197 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:31,979] Trial 198 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:32,035] Trial 196 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.
[I 2024-02-04 19:50:32,036] Trial 199 finished with value: -0.029139837603797823
and parameters: {'min_samples_leaf': 100, 'max_depth': 25}. Best is trial 10
with value: -0.029139837603797823.

CPU times: user 5min 49s, sys: 2.93 s, total: 5min 52s
Wall time: 39.8 s
```

```
[16]: %%time
      study_bagging.
        ↪optimize(partial(objective_bagging,train=train_1,labels=y_1,val=valid,val_labels=y_valid,va
        ↪n_trials=200,n_jobs=-1)
```

```
[I 2024-02-04 19:50:37,819] Trial 8 finished with value: -0.03513729520240121
and parameters: {'min_samples_leaf': 900, 'max_depth': 10, 'n_estimators': 10}.
Best is trial 8 with value: -0.03513729520240121.
[I 2024-02-04 19:50:42,062] Trial 2 finished with value: -0.03435772493864116
and parameters: {'min_samples_leaf': 700, 'max_depth': 20, 'n_estimators': 15}.
Best is trial 2 with value: -0.03435772493864116.
[I 2024-02-04 19:50:49,965] Trial 11 finished with value: -0.034797389358008066
```

and parameters: {'min_samples_leaf': 1100, 'max_depth': 10, 'n_estimators': 15}.
Best is trial 2 with value: -0.03435772493864116.
[I 2024-02-04 19:50:50,569] Trial 1 finished with value: -0.03495474050708804
and parameters: {'min_samples_leaf': 900, 'max_depth': 10, 'n_estimators': 35}.
Best is trial 2 with value: -0.03435772493864116.
[I 2024-02-04 19:50:53,368] Trial 4 finished with value: -0.034768886156408545
and parameters: {'min_samples_leaf': 700, 'max_depth': 25, 'n_estimators': 35}.
Best is trial 2 with value: -0.03435772493864116.
[I 2024-02-04 19:50:55,152] Trial 3 finished with value: -0.03474778233001556
and parameters: {'min_samples_leaf': 700, 'max_depth': 5, 'n_estimators': 35}.
Best is trial 2 with value: -0.03435772493864116.
[I 2024-02-04 19:50:55,804] Trial 0 finished with value: -0.03480384414958905
and parameters: {'min_samples_leaf': 500, 'max_depth': 25, 'n_estimators': 35}.
Best is trial 2 with value: -0.03435772493864116.
[I 2024-02-04 19:50:57,180] Trial 13 finished with value: -0.03416586779176917
and parameters: {'min_samples_leaf': 500, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:50:57,462] Trial 10 finished with value: -0.03466932795455917
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 20}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:50:57,487] Trial 9 finished with value: -0.03480384414958905
and parameters: {'min_samples_leaf': 500, 'max_depth': 25, 'n_estimators': 35}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:50:59,244] Trial 6 finished with value: -0.03480384414958905
and parameters: {'min_samples_leaf': 500, 'max_depth': 25, 'n_estimators': 35}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:50:59,838] Trial 5 finished with value: -0.034862678101923034
and parameters: {'min_samples_leaf': 700, 'max_depth': 10, 'n_estimators': 40}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:51:05,525] Trial 20 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 5}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:51:08,845] Trial 21 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 5}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:51:09,242] Trial 12 finished with value: -0.034975070607071584
and parameters: {'min_samples_leaf': 700, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 13 with value: -0.03416586779176917.
[I 2024-02-04 19:51:09,391] Trial 17 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:09,680] Trial 22 finished with value: -0.03333427583080588
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:14,795] Trial 23 finished with value: -0.03333427583080588
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:14,914] Trial 7 finished with value: -0.03470942569220651

and parameters: {'min_samples_leaf': 300, 'max_depth': 10, 'n_estimators': 50}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:15,463] Trial 24 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:19,165] Trial 14 finished with value: -0.03446305374236865
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:26,704] Trial 25 finished with value: -0.03466932795455917
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:27,524] Trial 26 finished with value: -0.03466932795455917
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:32,418] Trial 28 finished with value: -0.03466932795455917
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:33,044] Trial 29 finished with value: -0.03466932795455917
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:34,749] Trial 31 finished with value: -0.033663575969112885
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:35,075] Trial 18 finished with value: -0.03291149210788412
and parameters: {'min_samples_leaf': 100, 'max_depth': 20, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:36,103] Trial 32 finished with value: -0.033302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:37,366] Trial 30 finished with value: -0.03466932795455917
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:39,778] Trial 16 finished with value: -0.03470942569220651
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 50}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:40,760] Trial 19 finished with value: -0.03454215316042583
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 50}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:40,888] Trial 33 finished with value: -0.033302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:41,435] Trial 34 finished with value: -0.033302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:43,334] Trial 35 finished with value: -0.033302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:51:44,746] Trial 15 finished with value: -0.03310973787833042

and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 40}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:02,119] Trial 27 finished with value: -0.03470942569220651
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 50}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:07,781] Trial 37 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:08,589] Trial 38 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:10,903] Trial 39 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:11,538] Trial 41 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:13,067] Trial 40 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:14,323] Trial 42 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:14,495] Trial 43 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:15,771] Trial 44 finished with value: -0.0331953201875552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:16,373] Trial 46 finished with value: -0.03465446083708593
and parameters: {'min_samples_leaf': 900, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:16,860] Trial 47 finished with value: -0.03465446083708593
and parameters: {'min_samples_leaf': 900, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:19,511] Trial 48 finished with value: -0.03465446083708593
and parameters: {'min_samples_leaf': 900, 'max_depth': 10, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:20,611] Trial 53 finished with value: -0.034952171976912014
and parameters: {'min_samples_leaf': 1100, 'max_depth': 10, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:21,527] Trial 50 finished with value: -0.03465446083708593
and parameters: {'min_samples_leaf': 900, 'max_depth': 10, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:22,662] Trial 49 finished with value: -0.03476267620030073
and parameters: {'min_samples_leaf': 500, 'max_depth': 10, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:22,881] Trial 52 finished with value: -0.03465446083708593

and parameters: {'min_samples_leaf': 900, 'max_depth': 10, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:24,025] Trial 55 finished with value: -0.034135642774024595
and parameters: {'min_samples_leaf': 500, 'max_depth': 10, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:26,983] Trial 56 finished with value: -0.034135642774024595
and parameters: {'min_samples_leaf': 500, 'max_depth': 10, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:27,682] Trial 51 finished with value: -0.03487748071787899
and parameters: {'min_samples_leaf': 300, 'max_depth': 10, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:28,139] Trial 57 finished with value: -0.034135642774024595
and parameters: {'min_samples_leaf': 500, 'max_depth': 10, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:29,751] Trial 54 finished with value: -0.03487748071787899
and parameters: {'min_samples_leaf': 300, 'max_depth': 10, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:31,852] Trial 60 finished with value: -0.03302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:32,508] Trial 61 finished with value: -0.03302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:33,220] Trial 45 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:35,502] Trial 62 finished with value: -0.03302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:36,199] Trial 63 finished with value: -0.03302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:36,408] Trial 36 finished with value: -0.033594135114106936
and parameters: {'min_samples_leaf': 100, 'max_depth': 25, 'n_estimators': 50}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:43,832] Trial 59 finished with value: -0.03500550700150299
and parameters: {'min_samples_leaf': 500, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:47,991] Trial 72 finished with value: -0.03333427583080588
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:49,865] Trial 58 finished with value: -0.03482619968017989
and parameters: {'min_samples_leaf': 500, 'max_depth': 5, 'n_estimators': 40}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:52,103] Trial 73 finished with value: -0.03333427583080588
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:54,733] Trial 74 finished with value: -0.03333427583080588

and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:55,229] Trial 65 finished with value: -0.03446305374236865
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:57,247] Trial 66 finished with value: -0.03446305374236865
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:52:58,148] Trial 67 finished with value: -0.03446305374236865
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:00,693] Trial 69 finished with value: -0.03446305374236865
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:01,816] Trial 70 finished with value: -0.03446305374236865
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:01,908] Trial 71 finished with value: -0.03446305374236865
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:02,416] Trial 64 finished with value: -0.03456108149501443
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 40}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:04,972] Trial 78 finished with value: -0.03363575969112885
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:07,389] Trial 68 finished with value: -0.03456108149501443
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 40}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:09,469] Trial 81 finished with value: -0.033363575969112885
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:09,738] Trial 82 finished with value: -0.033363575969112885
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:10,244] Trial 83 finished with value: -0.033363575969112885
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:13,309] Trial 84 finished with value: -0.033363575969112885
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:14,004] Trial 86 finished with value: -0.03458477675326112
and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:15,958] Trial 87 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 20, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:16,461] Trial 85 finished with value: -0.03379701800513115

and parameters: {'min_samples_leaf': 300, 'max_depth': 20, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:16,524] Trial 88 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 20, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:18,220] Trial 90 finished with value: -0.03333427583080588
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:18,320] Trial 76 finished with value: -0.034910849081526106
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 30}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:19,905] Trial 75 finished with value: -0.03457798773714674
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 35}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:22,910] Trial 77 finished with value: -0.03457798773714674
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 35}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:24,891] Trial 91 finished with value: -0.03302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:28,595] Trial 96 finished with value: -0.03302346335825338
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:31,842] Trial 98 finished with value: -0.034658219824586015
and parameters: {'min_samples_leaf': 700, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:34,154] Trial 79 finished with value: -0.0346881578740951
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 45}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:36,383] Trial 80 finished with value: -0.0346881578740951
and parameters: {'min_samples_leaf': 300, 'max_depth': 5, 'n_estimators': 45}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:44,459] Trial 100 finished with value: -0.033693284050639996
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:46,650] Trial 92 finished with value: -0.03419849297941055
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 35}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:47,093] Trial 101 finished with value: -0.033693284050639996
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:47,224] Trial 93 finished with value: -0.03419849297941055
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 35}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:47,453] Trial 99 finished with value: -0.0327627301731833
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:54,980] Trial 102 finished with value: -0.0327627301731833

and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:56,925] Trial 95 finished with value: -0.03465288688145285
and parameters: {'min_samples_leaf': 100, 'max_depth': 5, 'n_estimators': 45}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:56,959] Trial 103 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:59,787] Trial 104 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:59,801] Trial 106 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:53:59,802] Trial 105 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:00,150] Trial 107 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:01,372] Trial 94 finished with value: -0.032703087643296005
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 35}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:09,163] Trial 89 finished with value: -0.03358950675457587
and parameters: {'min_samples_leaf': 100, 'max_depth': 20, 'n_estimators': 45}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:18,224] Trial 113 finished with value: -0.0327627301731833
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:18,259] Trial 111 finished with value: -0.0327627301731833
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:18,377] Trial 97 finished with value: -0.03358950675457587
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 45}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:19,593] Trial 112 finished with value: -0.0327627301731833
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:19,850] Trial 108 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:20,295] Trial 114 finished with value: -0.0327627301731833
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 15}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:21,607] Trial 110 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:23,484] Trial 109 finished with value: -0.032671460823214454

and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:25,749] Trial 115 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:33,604] Trial 116 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:42,554] Trial 117 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:42,631] Trial 119 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:42,865] Trial 118 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:44,161] Trial 120 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:44,336] Trial 121 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:44,597] Trial 122 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:45,649] Trial 123 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:48,065] Trial 124 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:50,411] Trial 125 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:54:59,554] Trial 126 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:07,649] Trial 127 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:07,973] Trial 128 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:09,044] Trial 129 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:09,781] Trial 131 finished with value: -0.032671460823214454

and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:10,423] Trial 130 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:11,155] Trial 132 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:11,547] Trial 133 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:14,007] Trial 134 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:15,514] Trial 135 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:25,235] Trial 136 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:38,743] Trial 137 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:39,343] Trial 138 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:41,205] Trial 139 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:41,377] Trial 140 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:42,731] Trial 143 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:42,937] Trial 141 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:43,102] Trial 142 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:45,636] Trial 144 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:47,987] Trial 145 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:53,230] Trial 153 finished with value: -0.034715852750727166

and parameters: {'min_samples_leaf': 1100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:54,827] Trial 149 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:55:57,508] Trial 146 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:06,442] Trial 150 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:07,398] Trial 157 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:08,084] Trial 151 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:08,840] Trial 152 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:10,241] Trial 158 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:10,609] Trial 154 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:10,792] Trial 147 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:11,003] Trial 148 finished with value: -0.033195320187552495
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 25}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:13,441] Trial 155 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:17,457] Trial 165 finished with value: -0.034658219824586015
and parameters: {'min_samples_leaf': 700, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:18,341] Trial 156 finished with value: -0.032671460823214454
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 20}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:19,273] Trial 159 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:19,989] Trial 160 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:21,032] Trial 161 finished with value: -0.03265847612796275

and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:21,277] Trial 162 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:22,906] Trial 163 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:23,224] Trial 164 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:23,608] Trial 166 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:25,995] Trial 167 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:30,229] Trial 168 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:30,999] Trial 169 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:31,892] Trial 170 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:32,340] Trial 171 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:33,413] Trial 172 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:34,168] Trial 173 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:35,756] Trial 175 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:35,944] Trial 174 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:36,045] Trial 176 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:38,798] Trial 177 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:42,961] Trial 178 finished with value: -0.03265847612796275

and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:43,620] Trial 179 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:44,617] Trial 180 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:45,065] Trial 181 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:45,100] Trial 187 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:45,750] Trial 182 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:46,896] Trial 183 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:48,427] Trial 184 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:48,652] Trial 186 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:48,773] Trial 185 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:49,815] Trial 188 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:50,153] Trial 189 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:55,191] Trial 197 finished with value: -0.034314294299898775
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 5}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:57,227] Trial 190 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:57,777] Trial 192 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:57,919] Trial 191 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:58,364] Trial 193 finished with value: -0.03265847612796275

and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:56:59,347] Trial 194 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:57:00,296] Trial 196 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:57:00,407] Trial 195 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:57:01,518] Trial 198 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.
[I 2024-02-04 19:57:01,682] Trial 199 finished with value: -0.03265847612796275
and parameters: {'min_samples_leaf': 100, 'max_depth': 15, 'n_estimators': 10}.
Best is trial 17 with value: -0.03265847612796275.

CPU times: user 59min 37s, sys: 19.6 s, total: 59min 57s
Wall time: 6min 29s

```
[17]: %%time
      study_rf.
        ↪optimize(partial(objective_rf,train=train_1,labels=y_1,val=valid,val_labels=y_valid,val_ret
        ↪n_trials=200,n_jobs=-1)
```

[I 2024-02-04 19:57:01,897] Trial 0 finished with value: -0.033294890464413515
and parameters: {'n_estimators': 10, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 6}. Best is trial 0 with value: -0.033294890464413515.
[I 2024-02-04 19:57:01,983] Trial 7 finished with value: -0.03312109365778519
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 9}. Best is trial 7 with value: -0.03312109365778519.
[I 2024-02-04 19:57:02,077] Trial 6 finished with value: -0.033087587056024326
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 13}. Best is trial 6 with value: -0.033087587056024326.
[I 2024-02-04 19:57:02,089] Trial 10 finished with value: -0.03305251857272103
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 6}. Best is trial 10 with value: -0.03305251857272103.
[I 2024-02-04 19:57:02,220] Trial 1 finished with value: -0.03352655896226559
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
1600, 'max_depth': 8}. Best is trial 10 with value: -0.03305251857272103.
[I 2024-02-04 19:57:02,221] Trial 2 finished with value: -0.03352655896226559
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 10 with value: -0.03305251857272103.
[I 2024-02-04 19:57:02,348] Trial 11 finished with value: -0.033087587056024326
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 14}. Best is trial 10 with value: -0.03305251857272103.
[I 2024-02-04 19:57:02,406] Trial 13 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':

2400, 'max_depth': 5}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,528] Trial 5 finished with value: -0.03373122428685451
and parameters: {'n_estimators': 25, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 8}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,643] Trial 12 finished with value: -0.03340635580774825
and parameters: {'n_estimators': 25, 'max_features': 'sqrt', 'min_samples_leaf':
1600, 'max_depth': 14}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,665] Trial 16 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 7}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,681] Trial 8 finished with value: -0.03325526608182135
and parameters: {'n_estimators': 30, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 9}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,717] Trial 14 finished with value: -0.03383085702416422
and parameters: {'n_estimators': 15, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 10}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,779] Trial 9 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 8}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,831] Trial 3 finished with value: -0.03320357841507952
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 6}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:02,929] Trial 4 finished with value: -0.03331924418841412
and parameters: {'n_estimators': 40, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 5}. Best is trial 13 with value: -0.032997758066637024.
[I 2024-02-04 19:57:03,034] Trial 17 finished with value: -0.03295654622276119
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 17 with value: -0.03295654622276119.
[I 2024-02-04 19:57:03,090] Trial 18 finished with value: -0.03306438402427945
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 14}. Best is trial 17 with value: -0.03295654622276119.
[I 2024-02-04 19:57:03,216] Trial 15 finished with value: -0.0331438190547435
and parameters: {'n_estimators': 40, 'max_features': 'sqrt', 'min_samples_leaf':
1600, 'max_depth': 6}. Best is trial 17 with value: -0.03295654622276119.
[I 2024-02-04 19:57:03,242] Trial 20 finished with value: -0.0331410474850021
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 4}. Best is trial 17 with value: -0.03295654622276119.
[I 2024-02-04 19:57:03,298] Trial 19 finished with value: -0.0331410474850021
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 4}. Best is trial 17 with value: -0.03295654622276119.
[I 2024-02-04 19:57:03,327] Trial 21 finished with value: -0.0331410474850021
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 4}. Best is trial 17 with value: -0.03295654622276119.
[I 2024-02-04 19:57:03,334] Trial 24 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 4}. Best is trial 17 with value: -0.03295654622276119.
[I 2024-02-04 19:57:03,413] Trial 22 finished with value: -0.0331410474850021
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':

2400, 'max_depth': 5}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,440] Trial 23 finished with value: -0.0331410474850021
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 4}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,466] Trial 25 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 4}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,717] Trial 28 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,724] Trial 27 finished with value: -0.0331410474850021
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,728] Trial 26 finished with value: -0.033308281286758778
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 12}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,799] Trial 29 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,845] Trial 30 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,886] Trial 32 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,910] Trial 31 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 10}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:03,932] Trial 33 finished with value: -0.032997758066637024
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
2400, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,041] Trial 35 finished with value: -0.032957298538870119
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,063] Trial 34 finished with value: -0.032957298538870119
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 11}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,281] Trial 38 finished with value: -0.032957298538870119
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 7}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,313] Trial 36 finished with value: -0.032957298538870119
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 12}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,351] Trial 41 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 7}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,378] Trial 37 finished with value: -0.032957298538870119
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':

1600, 'max_depth': 7}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,380] Trial 39 finished with value: -0.03295729853870119
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 7}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,397] Trial 43 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 7}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,450] Trial 40 finished with value: -0.03295729853870119
and parameters: {'n_estimators': 30, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 7}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,453] Trial 42 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 7}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,550] Trial 44 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,592] Trial 45 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,793] Trial 46 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,802] Trial 47 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,872] Trial 49 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,881] Trial 50 finished with value: -0.033120265826394504
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:04,975] Trial 48 finished with value: -0.033064384024227945
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:05,004] Trial 51 finished with value: -0.033064384024227945
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
1600, 'max_depth': 12}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:05,114] Trial 52 finished with value: -0.032956546222276119
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:05,154] Trial 53 finished with value: -0.032956546222276119
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:05,619] Trial 54 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 12}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:05,638] Trial 63 finished with value: -0.032956546222276119
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:05,707] Trial 55 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:05,777] Trial 57 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:05,852] Trial 56 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:05,883] Trial 58 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:05,979] Trial 59 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:06,023] Trial 60 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:06,023] Trial 61 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 9}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:06,175] Trial 62 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 17 with value: -0.032956546222276119.
[I 2024-02-04 19:57:06,202] Trial 70 finished with value: -0.03327889980613055
and parameters: {'n_estimators': 10, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 17 with value: -0.032956546222776119.
[I 2024-02-04 19:57:06,251] Trial 68 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,263] Trial 72 finished with value: -0.03327889980613055
and parameters: {'n_estimators': 10, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,297] Trial 71 finished with value: -0.03327889980613055
and parameters: {'n_estimators': 10, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,336] Trial 69 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,406] Trial 66 finished with value: -0.032956546222776119
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,463] Trial 67 finished with value: -0.032956546222776119
and parameters: {'n_estimators': 35, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,562] Trial 73 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,669] Trial 76 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,683] Trial 75 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,730] Trial 77 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,734] Trial 78 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,814] Trial 65 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,828] Trial 79 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,876] Trial 64 finished with value: -0.033208281164879554
and parameters: {'n_estimators': 35, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:06,889] Trial 80 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,035] Trial 81 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,051] Trial 82 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,102] Trial 74 finished with value: -0.033009717107784889
and parameters: {'n_estimators': 40, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,166] Trial 83 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,220] Trial 84 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,258] Trial 85 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,313] Trial 87 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,323] Trial 86 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,378] Trial 89 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,381] Trial 88 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,512] Trial 90 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,579] Trial 91 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,581] Trial 92 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,656] Trial 93 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,725] Trial 94 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,762] Trial 95 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,812] Trial 97 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 12}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,813] Trial 96 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 12}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,878] Trial 98 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 12}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,907] Trial 99 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 12}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,982] Trial 101 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:07,983] Trial 102 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,043] Trial 100 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,046] Trial 103 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,120] Trial 104 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,171] Trial 105 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,222] Trial 107 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,247] Trial 106 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,288] Trial 108 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,343] Trial 109 finished with value: -0.0330436449258485
and parameters: {'n_estimators': 15, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,459] Trial 111 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,464] Trial 110 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,522] Trial 112 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,536] Trial 113 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,587] Trial 114 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,656] Trial 115 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,717] Trial 117 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,718] Trial 116 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,816] Trial 118 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,823] Trial 119 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,958] Trial 120 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:08,979] Trial 121 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,021] Trial 123 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,026] Trial 122 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,076] Trial 124 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,136] Trial 125 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,292] Trial 126 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,297] Trial 127 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,377] Trial 129 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,437] Trial 128 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,451] Trial 130 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,490] Trial 131 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,637] Trial 133 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,648] Trial 134 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,685] Trial 132 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,701] Trial 135 finished with value: -0.033024219259405775
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,784] Trial 137 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,844] Trial 138 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,929] Trial 136 finished with value: -0.033024219259405770
and parameters: {'n_estimators': 25, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,956] Trial 139 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:09,983] Trial 140 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,013] Trial 141 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,134] Trial 142 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,177] Trial 143 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,214] Trial 145 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,226] Trial 144 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,296] Trial 146 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,358] Trial 147 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 8}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,496] Trial 148 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,507] Trial 149 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,572] Trial 150 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,630] Trial 151 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,699] Trial 152 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,755] Trial 153 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,804] Trial 154 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 10}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,824] Trial 156 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,830] Trial 155 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:10,920] Trial 157 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,014] Trial 159 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 10}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,030] Trial 158 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 10}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,121] Trial 160 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 10}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,129] Trial 161 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,226] Trial 162 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,260] Trial 163 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,346] Trial 165 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,358] Trial 164 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 15}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,372] Trial 166 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,421] Trial 167 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,528] Trial 168 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,533] Trial 169 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,598] Trial 171 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,641] Trial 170 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,715] Trial 172 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,772] Trial 173 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,862] Trial 174 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,863] Trial 175 finished with value: -0.03301245777526872
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 5}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,887] Trial 176 finished with value: -0.03301245777526872
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 5}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:11,907] Trial 177 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,031] Trial 178 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,059] Trial 179 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,111] Trial 180 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,172] Trial 181 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,232] Trial 182 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,275] Trial 183 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,553] Trial 184 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,578] Trial 185 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,623] Trial 186 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,636] Trial 187 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,742] Trial 188 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,744] Trial 189 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,824] Trial 191 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,845] Trial 190 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,855] Trial 192 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 13}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,922] Trial 194 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,937] Trial 193 finished with value: -0.03367020235388294
and parameters: {'n_estimators': 20, 'max_features': 'sqrt', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,975] Trial 195 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,997] Trial 196 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:12,998] Trial 197 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:13,045] Trial 198 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':
800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.
[I 2024-02-04 19:57:13,046] Trial 199 finished with value: -0.03292388157772522
and parameters: {'n_estimators': 20, 'max_features': 'log2', 'min_samples_leaf':

800, 'max_depth': 14}. Best is trial 68 with value: -0.03292388157772522.

```
CPU times: user 52.6 s, sys: 6.33 s, total: 58.9 s
Wall time: 11.4 s
```

0.1.3 Instantiate the classifiers with the best parameters

```
[18]: print("Best parameters for decision tree: ", study_tree.best_params)
      print("Best parameters for bagging: ", study_bagging.best_params)
      print("Best parameters for random forest: ", study_rf.best_params)
```

```
Best parameters for decision tree:  {'min_samples_leaf': 100, 'max_depth': 25}
Best parameters for bagging:  {'min_samples_leaf': 100, 'max_depth': 25,
'n_estimators': 10}
Best parameters for random forest:  {'n_estimators': 20, 'max_features': 'log2',
'min_samples_leaf': 800, 'max_depth': 14}
```

```
[19]: t_clf = DecisionTreeClassifier(**study_tree.best_params,random_state=123)
```

```
[20]: tree_cfl = DecisionTreeClassifier(**{'min_samples_leaf': study_bagging.
       ↪best_params['min_samples_leaf'],
                                          'max_depth': study_bagging.
       ↪best_params['max_depth']})
      bg_clf = BaggingClassifier(tree_cfl,n_estimators=study_bagging.
       ↪best_params['n_estimators'],random_state=123 ,n_jobs=-1)
```

```
[21]: rf_clf = RandomForestClassifier(**study_rf.best_params)
```

0.1.4 Train each of the classifiers

```
[22]: t_clf.fit(train_1,y_1)
```

```
[22]: DecisionTreeClassifier(max_depth=25, min_samples_leaf=100, random_state=123)
```

```
[23]: bg_clf.fit(train_1,y_1)
```

```
[23]: BaggingClassifier(estimator=DecisionTreeClassifier(max_depth=25,
                                                         min_samples_leaf=100),
                        n_jobs=-1, random_state=123)
```

```
[24]: rf_clf.fit(train_1,y_1)
```

```
[24]: RandomForestClassifier(max_depth=14, max_features='log2', min_samples_leaf=800,
                             n_estimators=20)
```

0.1.5 Finding the features with non zero Shapley values

```python
[25]: # Retrain the models using the original training set (i.e. before backtesting)
      t_clf.fit(train_1,y_1)
      bg_clf.fit(train_1,y_1)
      rf_clf.fit(train_1,y_1)
```

```
[25]: RandomForestClassifier(max_depth=14, max_features='log2', min_samples_leaf=800,
                             n_estimators=20)
```

```python
[26]: # Obtain the feature importances
      def tree_feat_importance(m, df):
          return pd.DataFrame({'cols':df.columns, 'feat_imp':m.feature_importances_}
                              ).sort_values('feat_imp', ascending=False)

      def bagging_feat_importance(m, df):
          feature_importances = []
          for est in m.estimators_:
              fi = est.feature_importances_
              feature_importances.append(fi)
          feature_importances = np.array(feature_importances)

          return pd.DataFrame({'cols':train_1.columns, 'feat_imp':np.
       ↪mean(feature_importances,axis=0)}
                              ).sort_values('feat_imp', ascending=False)

      def randomforest_feat_importances(m, df):

          return pd.DataFrame({'cols':df.columns, 'feat_imp': m.feature_importances_}
                              ).sort_values('feat_imp', ascending=False)

      def plot_fi(fi): return fi.plot('cols', 'feat_imp', 'barh', figsize=(12,7),␣
       ↪legend=False)
```

```python
[27]: t_fi = tree_feat_importance(t_clf,train_1)
      bg_fi = bagging_feat_importance(bg_clf,train_1)
      rf_fi = randomforest_feat_importances(rf_clf,train_1)
```

```python
[28]: # Only use features that have positive feature importance
      t_features = t_fi[(t_fi['feat_imp'] > 0.00)]
      bg_features = bg_fi[(bg_fi['feat_imp'] > 0.00)]
      rf_features = rf_fi[(rf_fi['feat_imp'] > 0.00)]
```

```python
[29]: train_t = train_1[t_features['cols'].values]
      valid_t = valid[t_features['cols'].values]
      valid_t['returns'] = valid_stock_returns.values

      train_bg = train_1[bg_features['cols'].values]
```

```
valid_bg = valid[bg_features['cols'].values]
valid_bg['returns'] = valid_stock_returns.values

train_rf = train_1[rf_features['cols'].values]
valid_rf = valid[rf_features['cols'].values]
valid_rf['returns'] = valid_stock_returns.values
```

[30]:
```
print(f"Number of features used for decision tree classifier reduced from:␣
  ↪{train_1.shape[1]} to {train_t.shape[1]}")
print(f"Number of features used for bagging classifier reduced from      :␣
  ↪{train_1.shape[1]} to {train_bg.shape[1]}")
print(f"Number of features used for random forest classifier reduced from:␣
  ↪{train_1.shape[1]} to {train_rf.shape[1]}")
```

```
Number of features used for decision tree classifier reduced from: 725 to 84
Number of features used for bagging classifier reduced from      : 725 to 169
Number of features used for random forest classifier reduced from: 725 to 87
```

[31]:
```
# Retrain the classifiers using the new feature set
t_clf.fit(train_t,y_1)
bg_clf.fit(train_bg,y_1)
rf_clf.fit(train_rf,y_1)
```

[31]:
```
RandomForestClassifier(max_depth=14, max_features='log2', min_samples_leaf=800,
                       n_estimators=20)
```

[32]:
```
import shap

def model_t(features):
    tree_features = features[features.columns[:-1].values]
    # Use predict_proba and the conviction definition of profit
    probs = t_clf.predict_proba(tree_features)
    conviction = probs[:, 2] - probs[:, 0]  # Prob_s(+1) - Prob_s(-1)
    weights = conviction / np.sum(np.abs(conviction))
    ret = weights * features[features.columns[-1]]
    return ret

def model_bg(features):
    bagging_features = features[features.columns[:-1].values]
    # Use predict_proba and the conviction definition of profit
    probs = bg_clf.predict_proba(bagging_features)
    conviction = probs[:, 2] - probs[:, 0]   # Prob_s(+1) - Prob_s(-1)
    weights = conviction / np.sum(np.abs(conviction))
    ret = weights * features[features.columns[-1]]
    return ret

def model_rf(features):
    rf_features = features[features.columns[:-1].values]
```

```
        probs = rf_clf.predict_proba(rf_features)
        conviction = probs[:, 2] - probs[:, 0]   # Prob_s(+1) - Prob_s(-1)
        weights = conviction / np.sum(np.abs(conviction))
        ret = weights * features[features.columns[-1]]
        return ret
```
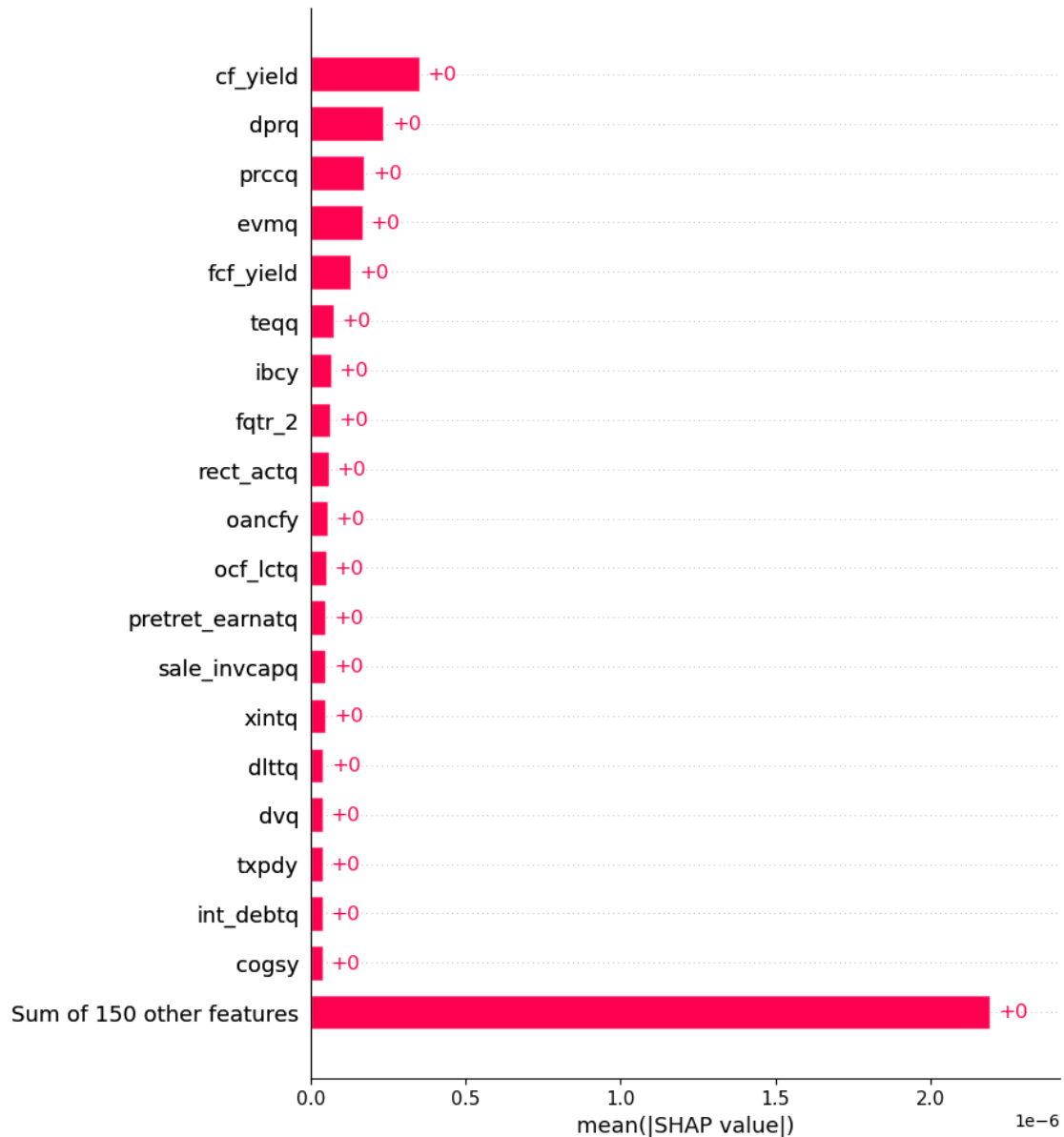
[33]:
```
# Shapley for tree classifier
model_t(valid_t)
t_explainer = shap.explainers.Permutation(model_t,valid_t)
t_shap_values = t_explainer(valid_t,max_evals=2000)
shap.plots.bar(t_shap_values[:,:-1],max_display=10)
```

PermutationExplainer explainer: 1442it [01:42, 12.76it/s]
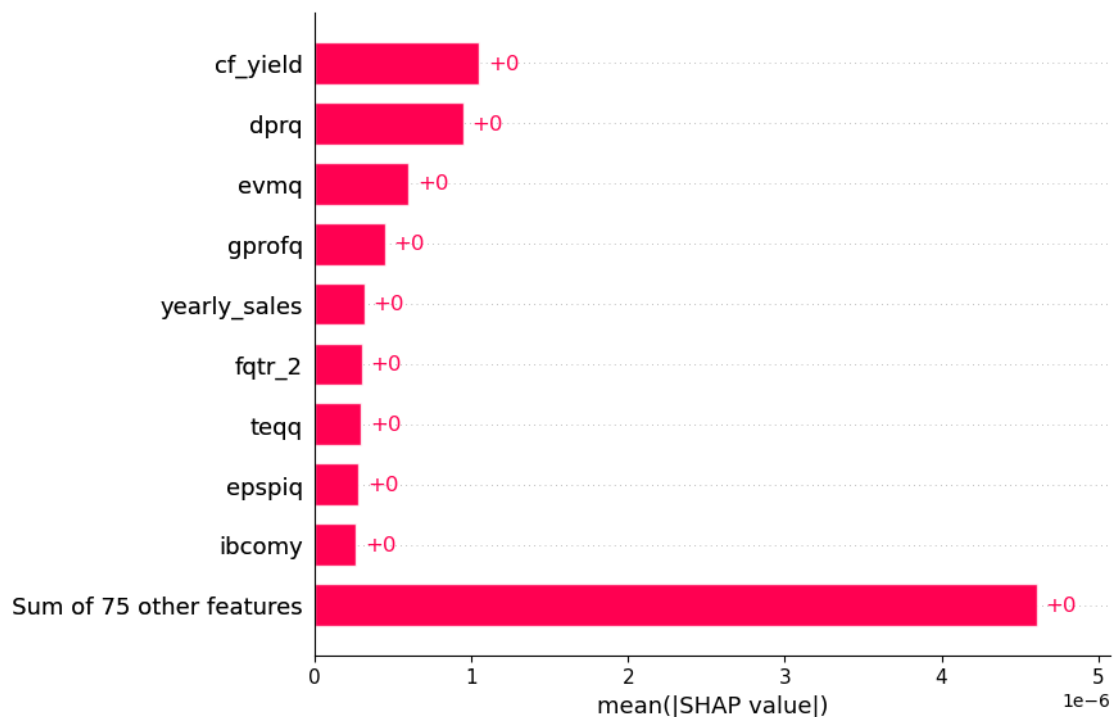
[34]:
```
# Shapley for bagging classifier
model_bg(valid_bg)
bg_explainer = shap.explainers.Permutation(model_bg,valid_bg)
bg_shap_values = bg_explainer(valid_bg,max_evals=2000)
shap.plots.bar(bg_shap_values[:,:-1],max_display=20)
```

PermutationExplainer explainer: 1442it [31:31, 1.32s/it]

```
[35]:  # Shapley for random forest classifier
       model_rf(valid_rf)
       rf_explainer = shap.explainers.Permutation(model_rf,valid_rf)
       rf_shap_values = rf_explainer(valid_rf,max_evals=2000)
       shap.plots.bar(rf_shap_values[:,:-1],max_display=20)
```

PermutationExplainer explainer: 1442it [03:47, 6.06it/s]
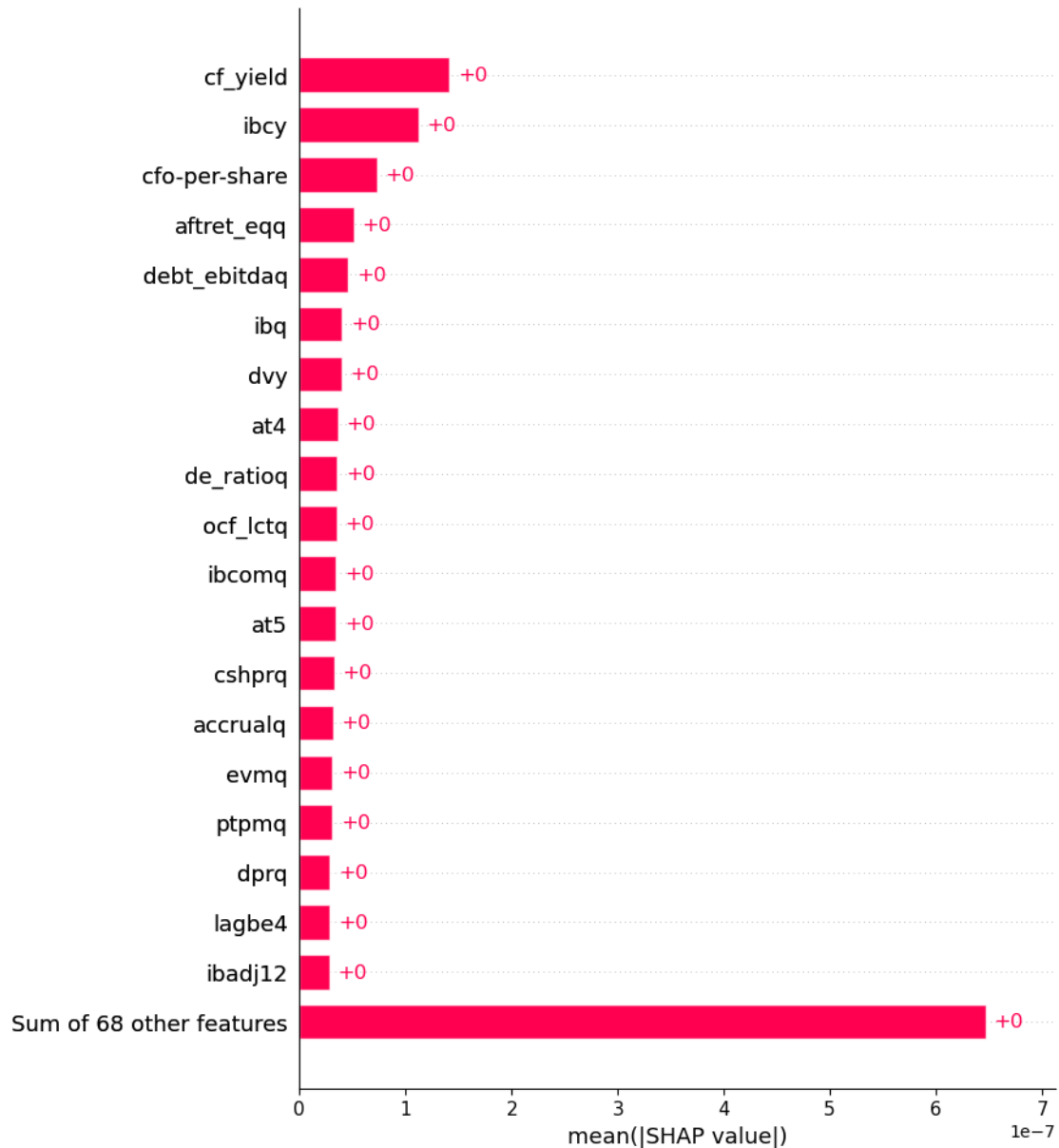
0.1.6 Retrain the models with the features that have non-zero Shapley values

```
[36]: t_cols = t_features['cols'].values
t_shap_cols = t_cols[np.abs(t_shap_values[:,:-1].values).mean(axis=0)>0.000]

bg_cols = bg_features['cols'].values
bg_shap_cols = bg_cols[np.abs(bg_shap_values[:,:-1].values).mean(axis=0)>0.000]

rf_cols = rf_features['cols'].values
rf_shap_cols = rf_cols[np.abs(rf_shap_values[:,:-1].values).mean(axis=0)>0.000]
```

```
[37]: t_clf.fit(train_t[t_shap_cols],y_1)
      bg_clf.fit(train_bg[bg_shap_cols],y_1)
      rf_clf.fit(train_rf[rf_shap_cols],y_1)
```

```
[37]: RandomForestClassifier(max_depth=14, max_features='log2', min_samples_leaf=800,
                             n_estimators=20)
```

0.1.7 Back test over the period 2010 - 2018

```
[38]: start_dates = [pd.to_datetime('2010-01-01') + pd.DateOffset(months = 3*i) for i␣
       ↪in range(21)]
      end_dates = [d + pd.DateOffset(months = 36) for d in start_dates]
      # So the first period is [2010 Jan 1 - 2013 Jan 1], and the last period is␣
       ↪[2015 Jan 1 - 2018 Jan 1]
```

```
[39]: training_frames = [data.loc[d:d+pd.DateOffset(months = 36)] for d in␣
       ↪start_dates]
      valid_frames = [data.loc[d + pd.DateOffset(months=3):d+pd.DateOffset(months =␣
       ↪6)] for d in end_dates]
      test_frames = [data.loc[d + pd.DateOffset(months=6):d+pd.DateOffset(months =␣
       ↪9)] for d in end_dates]

      training_labels = [d['rel_performance'].values for d in training_frames]

      training_stock_returns = [d['next_period_return'].values for d in␣
       ↪training_frames]
      test_stock_returns = [d['next_period_return'] for d in test_frames]
```

```
[40]: training_data = [df.reset_index().drop(['ticker','date',
                                              'next_period_return',
                                              'spy_next_period_return',
                                              'rel_performance', 'pred_rel_return',
                                              'return', 'cum_ret', 'spy_cum_ret'],axis=1)␣
       ↪for df in training_frames]
      valid_data = [df.reset_index().drop(['ticker','date',
                                           'next_period_return',
                                           'spy_next_period_return',
                                           'rel_performance','pred_rel_return',
                                           'return', 'cum_ret', 'spy_cum_ret'],axis=1)␣
       ↪for df in valid_frames]
      test_data = [df.reset_index().drop(['ticker','date',
                                          'next_period_return',
                                          'spy_next_period_return',
                                          'rel_performance','pred_rel_return',
                                          'return', 'cum_ret', 'spy_cum_ret'],axis=1)␣
       ↪for df in test_frames]
```

```
[41]: scalers = [StandardScaler() for _ in range(len(training_data))]

      def get_opt_data(shap_cols):
          opt_training_data = [pd.DataFrame(scalers[i].
       ↪fit_transform(training_frames[i][shap_cols].values),columns=shap_cols) for i↳
       ↪in range(len(training_data))]
          opt_valid_data = [pd.DataFrame(scalers[i].
       ↪transform(valid_frames[i][shap_cols].values),columns=shap_cols) for i in↳
       ↪range(len(valid_data))]
          opt_test_data = [pd.DataFrame(scalers[i].
       ↪transform(test_frames[i][shap_cols].values),columns=shap_cols) for i in↳
       ↪range(len(test_data))]
          return opt_training_data, opt_valid_data, opt_test_data

      t_opt_training_data, t_opt_valid_data, t_opt_test_data =↳
       ↪get_opt_data(t_shap_cols)
      bg_opt_training_data, bg_opt_valid_data, bg_opt_test_data =↳
       ↪get_opt_data(bg_shap_cols)
      rf_opt_training_data, rf_opt_valid_data, rf_opt_test_data =↳
       ↪get_opt_data(rf_shap_cols)
```

```
[42]: # dictionary to store performance and returns
      opt_xs = {'t':[1], 'bg':[1], 'rf':[1]}
      opt_rets = {'t':[], 'bg':[], 'rf':[]}
      models = {'t':t_clf, 'bg':bg_clf, 'rf':rf_clf}

      # dictionary of training and test data for each classifier model
      opt_training_data = {'t':t_opt_training_data, 'bg':bg_opt_training_data, 'rf':
       ↪rf_opt_training_data}
      opt_test_data = {'t':t_opt_test_data, 'bg':bg_opt_test_data, 'rf':
       ↪rf_opt_test_data}

      for i in tqdm(range(len(start_dates)-1)):
          for key, model in models.items():
              model.fit(opt_training_data[key][i],training_labels[i])

              preds = model.predict(opt_test_data[key][i])
              profit_i = (preds*test_stock_returns[i]).sum()

              opt_rets[key].append(profit_i)
              num_names = len(opt_test_data[key][i])
              opt_xs[key].append(opt_xs[key][i] + (opt_xs[key][i]/num_names)*profit_i)
```
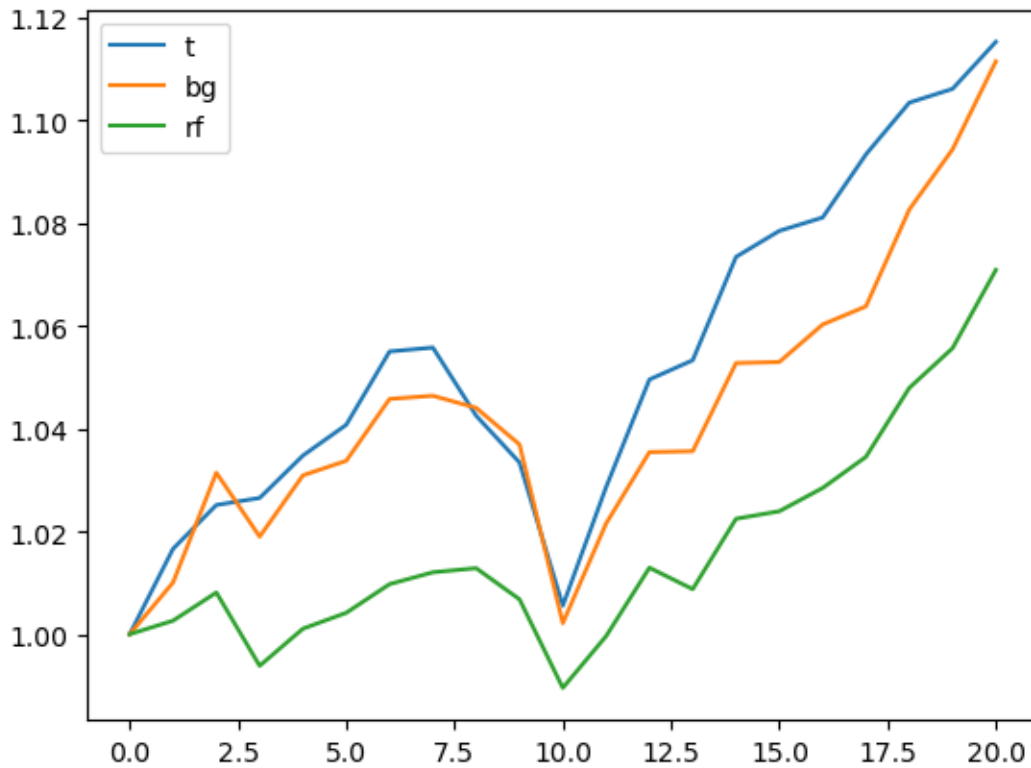
```
100%|                              | 20/20 [01:12<00:00,  3.62s/it]
```
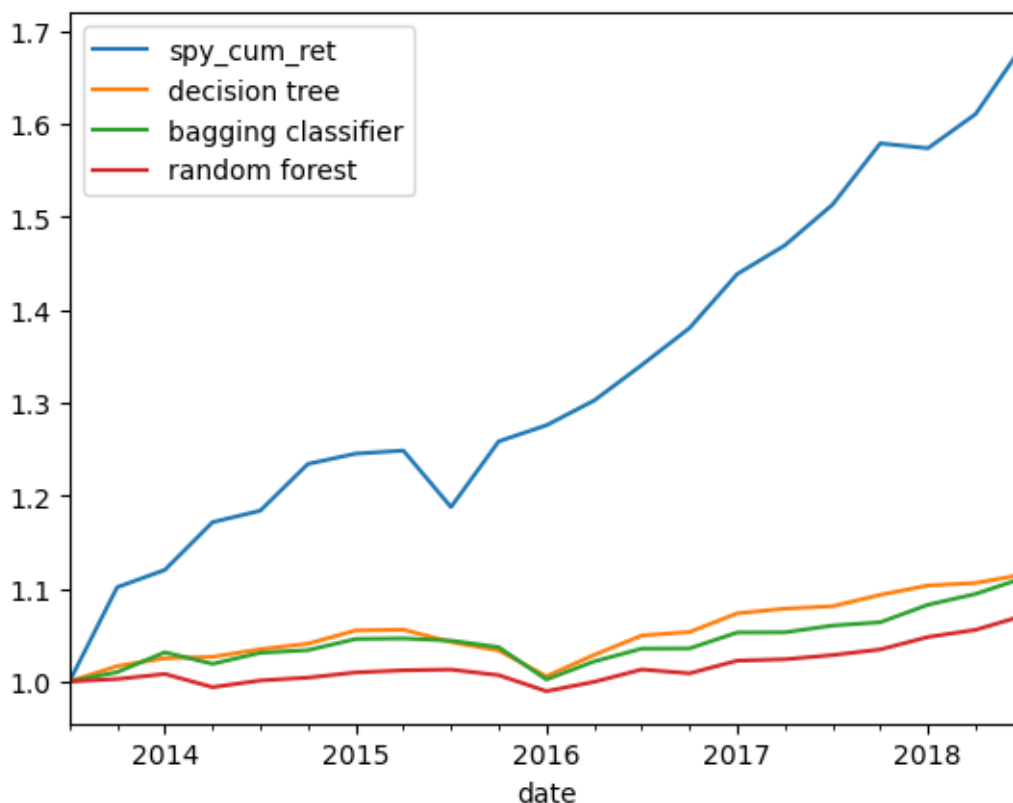
```
[54]: for key, x_list in opt_xs.items():
          plt.plot(x_list, label = key);
```

```
plt.legend()
```

[54]: <matplotlib.legend.Legend at 0x2e55a7e10>

[55]:
```python
# Compare to buy and hold of SPY
SPY = pd.read_pickle(r'SPY_cum_ret.pkl')
SPY = SPY.loc['2013-07-01':'2018-09-30']
SPY = SPY.resample('Q').ffill()
SPY['spy_cum_ret'] = (SPY['spy_cum_ret'] - SPY['spy_cum_ret'][0]+1)
SPY['decision tree'] = opt_xs['t']
SPY['bagging classifier'] = opt_xs['bg']
SPY['random forest'] = opt_xs['rf']
SPY.plot();
```

0.1.8 Compute the Sharpe Ratio, Information Ratio, and alpha for the strategies and for the buy-and-hold strategy for SPY

```
[56]: strategies = {'decision tree' :      "Decision Tree Strategy      ",
                    'bagging classifier': "Bagging Classifier Strategy",
                    'random forest' :     "Random Forest Strategy      ",
                    'spy_cum_ret':        "SPY Buy-and-hold Strategy  "}
```

```
[57]: # Sharpe Ratio
      for key, strat in strategies.items():
          strategy_mean_ret = (SPY[key] - 1).diff().mean()
          strategy_std = (SPY[key] - 1).diff().std()
          strategy_sr = strategy_mean_ret/strategy_std
          print(strat, ' Sharpe Ratio:', strategy_sr)
```

```
Decision Tree Strategy       Sharpe Ratio: 0.47523455895031175
Bagging Classifier Strategy  Sharpe Ratio: 0.4187276875359691
Random Forest Strategy       Sharpe Ratio: 0.4076851619586382
SPY Buy-and-hold Strategy    Sharpe Ratio: 0.9869583355280026
```

```python
[58]:  # Information Ratio
       spy_ret = (SPY['spy_cum_ret'] - 1).diff().values[1:]

       for key, strat in list(strategies.items())[:-1]:
           strategy_ret = (SPY[key] - 1).diff().values[1:]
           beta = (np.cov(spy_ret,strategy_ret)/np.var(spy_ret))[1,0]
           residual_ret = strategy_ret - beta * spy_ret
           IR = np.mean(residual_ret)/np.std(residual_ret)
           print(strat, ' Information Ratio:', IR)
```

```
Decision Tree Strategy        Information Ratio: 0.12851206603115614
Bagging Classifier Strategy   Information Ratio: 0.35241553371504525
Random Forest Strategy        Information Ratio: 0.3910570649408755
```

```python
[59]:  # Alpha
       for key, strat in list(strategies.items())[:-1]:
           strategy_ret = (SPY[key] - 1).diff().values[1:]
           beta = (np.cov(spy_ret,strategy_ret)/np.var(spy_ret))[1,0]
           residual_ret = strategy_ret - beta * spy_ret
           alpha = np.mean(residual_ret)
           print(strat, ' alpha:', alpha)
```

```
Decision Tree Strategy        alpha: 0.0014250818852215128
Bagging Classifier Strategy   alpha: 0.004555065833868771
Random Forest Strategy        alpha: 0.0033088661970511026
```