In [1]:
```
# This Python 3 environment comes with many helpful analytics libraries installed
# It is defined by the kaggle/python Docker image: https://github.com/kaggle/docker-python
# For example, here's several helpful packages to load

import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the read-only "../input/" directory
# For example, running this (by clicking run or pressing Shift+Enter) will list all files under the input direct

import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))

# You can write up to 5GB to the current directory (/kaggle/working/) that gets preserved as output when you cre
# You can also write temporary files to /kaggle/temp/, but they won't be saved outside of the current session
```

```
/kaggle/input/usaid-final-submission/submission_format.csv
/kaggle/input/usaid-final-submission/contraceptive_logistics_data.csv
/kaggle/input/usaidfinalsubmission/service_delivery_site_data.csv
```

In [2]:
```
%matplotlib inline
pd.set_option('display.max_rows', 500)
pd.set_option('display.max_columns', 500)
import seaborn as sns
import matplotlib.pyplot as plt
import time



from sklearn.model_selection import train_test_split,GridSearchCV
import matplotlib.pylab as plt
from xgboost import XGBRegressor
from sklearn.model_selection import RandomizedSearchCV
from sklearn.metrics import mean_squared_error
from math import sqrt
```

In [3]:
```
train=pd.read_csv('../input/usaid-final-submission/contraceptive_logistics_data.csv')
sub = pd.read_csv('../input/usaid-final-submission/submission_format.csv')
test = pd.read_csv('../input/usaid-final-submission/submission_format.csv')
sd=pd.read_csv('../input/usaidfinalsubmission/service_delivery_site_data.csv')
```

In [4]:
```
train.columns
```

Out[4]:
```
Index(['year', 'month', 'region', 'district', 'site_code', 'product_code',
       'stock_initial', 'stock_received', 'stock_distributed',
       'stock_adjustment', 'stock_end', 'average_monthly_consumption',
       'stock_stockout_days', 'stock_ordered'],
      dtype='object')
```

In [5]:
```
test.columns
```

Out[5]:
```
Index(['year', 'month', 'site_code', 'product_code', 'predicted_value'], dtype='object')
```

In [6]:
```
test.head()
```

Out[6]:

	year	month	site_code	product_code	predicted_value
0	2019	10	C4001	AS27134	0
1	2019	10	C4001	AS27132	0
2	2019	10	C4001	AS27000	0
3	2019	10	C4001	AS27137	0
4	2019	10	C4001	AS27138	0

In [7]:
```
sd.columns
```

Out[7]:
```
Index(['site_code', 'site_type', 'site_region', 'site_district',
       'site_latitude', 'site_longitude'],
      dtype='object')
```

In [8]:
```
#drop columns in the training data that are not useful for builing the model
train.drop(columns={'stock_initial', 'stock_received','stock_adjustment',
                    'stock_end', 'average_monthly_consumption',
                    'stock_stockout_days', 'stock_ordered'},inplace=True)
```

In [9]:
```
test.drop(['predicted_value'], axis =1, inplace = True)
```

In [10]:
```
test.head()
```

Out[10]:

	year	month	site_code	product_code
0	2019	10	C4001	AS27134
1	2019	10	C4001	AS27132
2	2019	10	C4001	AS27000
3	2019	10	C4001	AS27137
4	2019	10	C4001	AS27138

In [11]:
```
test.dtypes
```

Out[11]:
```
year             int64
month            int64
site_code       object
product_code    object
dtype: object
```

In [12]:
```
test=pd.merge(test,sd,on='site_code',how='left') #Merge test data with service delivery site data
test.rename(columns={'site_region':'region','site_district':'district'},inplace=True)
test=test[['year', 'month', 'region','district','site_code', 'product_code']]
```

In [13]:
```
train.head(2).append(test.head(2))
```

Out[13]:

	year	month	region	district	site_code	product_code	stock_distributed
0	2019	1	INDENIE-DJUABLIN	ABENGOUROU	C4001	AS27134	21.0
1	2019	1	INDENIE-DJUABLIN	ABENGOUROU	C4001	AS27132	3.0
0	2019	10	INDENIE-DJUABLIN	ABENGOUROU	C4001	AS27134	NaN
1	2019	10	INDENIE-DJUABLIN	ABENGOUROU	C4001	AS27132	NaN

In [14]:
```
train['train_or_test']='train'
test['train_or_test']='test'
df=pd.concat([train,test])
```

In [15]:
```
#Label encode region, district, site_code and product_code so its values can be accepted by the model
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()

for col in ['region','district','site_code','product_code']:
    df[col]=  df[col].astype('str')
    df[col]= le.fit_transform(df[col])
```

In [16]:
```
train=df.loc[df.train_or_test.isin(['train'])]
test=df.loc[df.train_or_test.isin(['test'])]
train.drop(columns={'train_or_test'},axis=1,inplace=True)
test.drop(columns={'train_or_test'},axis=1,inplace=True)
```

```
/opt/conda/lib/python3.7/site-packages/pandas/core/frame.py:4164: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#re
turning-a-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-
a-view-versus-a-copy)
  errors=errors,
```

In [17]:
```
train.head()
```

Out[17]:

	year	month	region	district	site_code	product_code	stock_distributed
0	2019	1	11	0	119	5	21.0
1	2019	1	11	0	119	3	3.0
2	2019	1	11	0	119	2	22.0
3	2019	1	11	0	119	6	0.0
4	2019	1	11	0	119	7	2.0

In [18]:
```
train.year.unique()
```

Out[18]:
```
array([2019, 2018, 2017, 2016])
```

In [19]:
```
test.head()
```

Out[19]:

	year	month	region	district	site_code	product_code	stock_distributed
0	2019	10	11	0	119	5	NaN
1	2019	10	11	0	119	3	NaN
2	2019	10	11	0	119	2	NaN
3	2019	10	11	0	119	6	NaN
4	2019	10	11	0	119	7	NaN

In [20]:
```
test.year.unique()
```

Out[20]:
```
array([2019])
```

In [21]:
```
#convert product code in both train and test data from numerical variable to categorical variable
train['product_code'] = train['product_code'].astype('category')
test['product_code'] = test['product_code'].astype('category')
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#re
turning-a-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-
a-view-versus-a-copy)

/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#re
turning-a-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-
a-view-versus-a-copy)
  This is separate from the ipykernel package so we can avoid doing imports until
```

In [22]:
```
train = pd.get_dummies(train, drop_first = True)
test = pd.get_dummies(test, drop_first = True)
```

In [23]:
```
train.columns
```

Out[23]:
```
Index(['year', 'month', 'region', 'district', 'site_code', 'stock_distributed',
       'product_code_1', 'product_code_2', 'product_code_3', 'product_code_4',
       'product_code_5', 'product_code_6', 'product_code_7', 'product_code_8',
       'product_code_9', 'product_code_10'],
      dtype='object')
```

In [24]:
```
test.columns
```

Out[24]:
```
Index(['year', 'month', 'region', 'district', 'site_code', 'stock_distributed',
       'product_code_1', 'product_code_2', 'product_code_3', 'product_code_4',
       'product_code_5', 'product_code_6', 'product_code_7', 'product_code_8',
       'product_code_9', 'product_code_10'],
      dtype='object')
```

In [25]:
```
train.columns
```

Out[25]:
```
Index(['year', 'month', 'region', 'district', 'site_code', 'stock_distributed',
       'product_code_1', 'product_code_2', 'product_code_3', 'product_code_4',
       'product_code_5', 'product_code_6', 'product_code_7', 'product_code_8',
       'product_code_9', 'product_code_10'],
      dtype='object')
```

In [26]:
```
#both test and submission data have the same number of records after data preprocessing
len(test), len(sub)
```

Out[26]:
```
(3115, 3115)
```

In [27]:
```
train.head()
```

Out[27]:

	year	month	region	district	site_code	stock_distributed	product_code_1	product_code_2	product_code_3	product_code_4	product
0	2019	1	11	0	119	21.0	0	0	0	0	
1	2019	1	11	0	119	3.0	0	0	1	0	
2	2019	1	11	0	119	22.0	0	1	0	0	
3	2019	1	11	0	119	0.0	0	0	0	0	
4	2019	1	11	0	119	2.0	0	0	0	0	

In [28]:
```
test.head()
```

Out[28]:

	year	month	region	district	site_code	stock_distributed	product_code_1	product_code_2	product_code_3	product_code_4	product
0	2019	10	11	0	119	NaN	0	0	0	0	
1	2019	10	11	0	119	NaN	0	0	1	0	
2	2019	10	11	0	119	NaN	0	1	0	0	
3	2019	10	11	0	119	NaN	0	0	0	0	
4	2019	10	11	0	119	NaN	0	0	0	0	

In [29]:
```
train.corr()
```

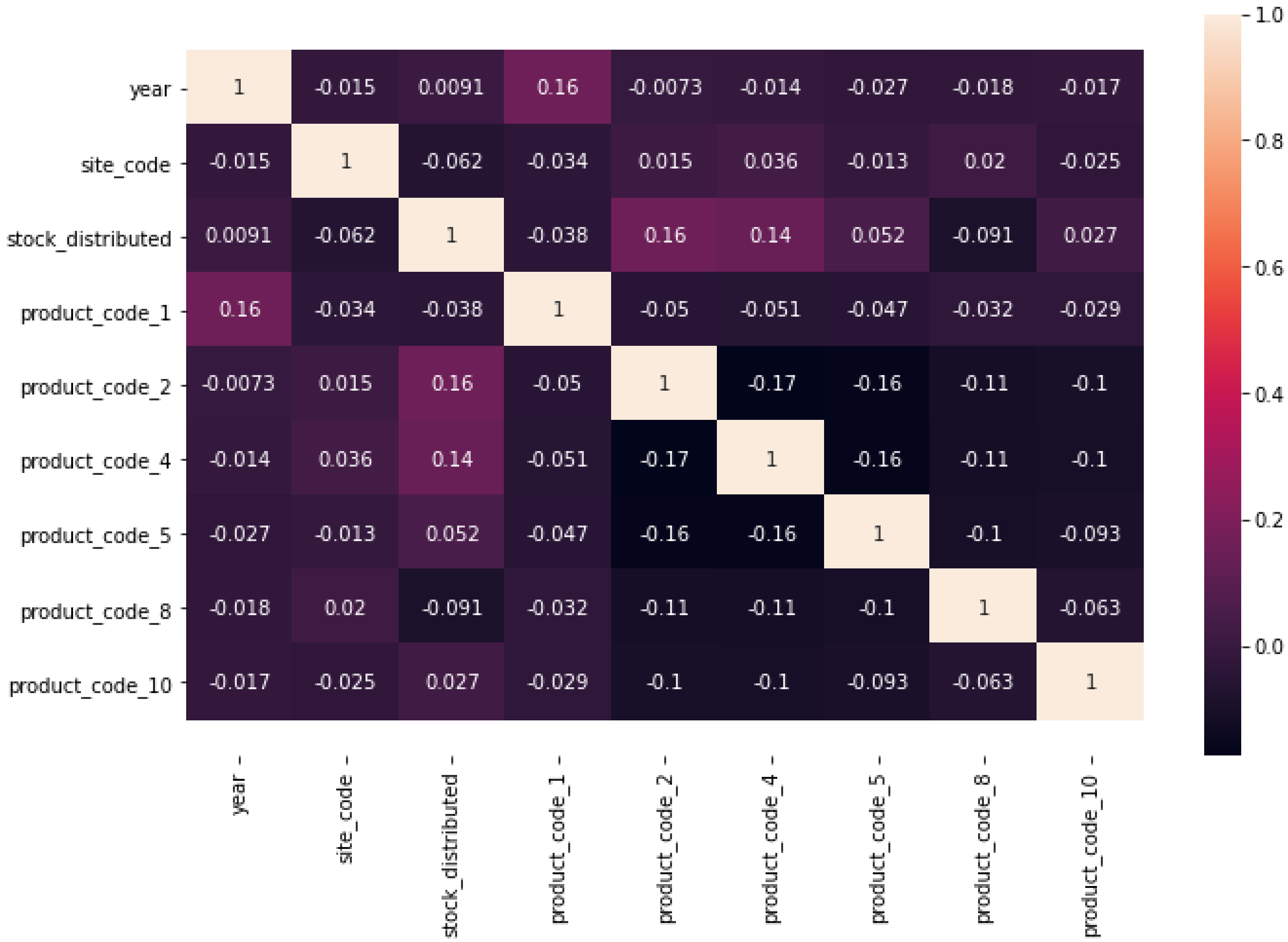
Out[29]:

	year	month	region	district	site_code	stock_distributed	product_code_1	product_code_2	product_code_
year	1.000000	-0.191016	-0.028990	-0.016426	-0.015245	0.009055	0.156266	-0.007252	-0.0119
month	-0.191016	1.000000	-0.001431	0.001167	0.002958	0.004145	-0.009155	0.002897	0.0005
region	-0.028990	-0.001431	1.000000	-0.009061	0.520614	-0.030530	-0.037977	0.005724	-0.0136
district	-0.016426	0.001167	-0.009061	1.000000	0.094775	-0.025625	-0.004275	-0.020570	0.0045
site_code	-0.015245	0.002958	0.520614	0.094775	1.000000	-0.062439	-0.033595	0.014692	-0.0117
stock_distributed	0.009055	0.004145	-0.030530	-0.025625	-0.062439	1.000000	-0.037728	0.158383	-0.0886
product_code_1	0.156266	-0.009155	-0.037977	-0.004275	-0.033595	-0.037728	1.000000	-0.049957	-0.0451
product_code_2	-0.007252	0.002897	0.005724	-0.020570	0.014692	0.158383	-0.049957	1.000000	-0.1555
product_code_3	-0.011982	0.000583	-0.013614	0.004507	-0.011797	-0.088686	-0.045124	-0.155510	1.0000
product_code_4	-0.013596	-0.002013	0.022181	-0.029640	0.035514	0.141248	-0.050540	-0.174176	-0.1573
product_code_5	-0.027153	0.000126	-0.018690	-0.018258	-0.013000	0.052328	-0.046570	-0.160493	-0.1449
product_code_6	0.006429	0.000730	0.015869	-0.001128	0.011098	-0.076418	-0.045441	-0.156601	-0.1414
product_code_7	0.044771	0.000397	-0.004848	0.007058	0.012047	-0.071193	-0.043440	-0.149707	-0.1352
product_code_8	-0.018397	-0.002231	0.049511	0.048489	0.019765	-0.090831	-0.031619	-0.108967	-0.0984
product_code_9	-0.003149	0.013983	-0.007973	0.028481	-0.021152	-0.075334	-0.025287	-0.087146	-0.0787
product_code_10	-0.017107	-0.002652	-0.016273	-0.010105	-0.024723	0.027305	-0.029015	-0.099994	-0.0903

In [30]:
```
#a further dropping of variables that are not useful to the model due to multicollinearity effect
train.drop(columns = ['month', 'district', 'region', 'product_code_6', 'product_code_3', 'product_code_7', 'proc
test.drop(columns = ['month', 'district', 'region', 'product_code_6', 'product_code_3', 'product_code_7', 'produ
```

In [31]:
```
corr = train.corr()
fig, ax = plt.subplots()
fig.set_size_inches(11, 7)
sns.heatmap(corr, xticklabels=corr.columns, yticklabels=corr.columns,annot = True, ax = ax)
bottom, top = ax.get_ylim()
ax.set_ylim(bottom + 0.5, top - 0.5)
```

Out[31]: (9.5, -0.5)



In [32]:
```
#this code takes care of invalid zeros in cases where stock_distributed for a contraceptive product at a service
train['stock_distributed'] = np.where(train['stock_distributed'] == 0, train['stock_distributed'].median(),
                                      train['stock_distributed'])
```

In [33]:
```
#split the data into 60% training set and 40% validation set
X=train.drop(columns={'stock_distributed'})
y=train.loc[:,['stock_distributed']]
del test['stock_distributed']


train_X, valid_X, train_y, valid_y = train_test_split(X, y, test_size=0.4, random_state=15)
```

In [34]:
```
#Define the model
my_model = XGBRegressor()
```

In [35]:
```
##Hyper Parameter Optimization
booster = ['gbtree', 'gblinear']
base_score = [0.25, 0.5, 0.75, 1]
eta = [0.01, 0.015, 0.025, 0.05, 0.1]
gamma = [0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.3, 0.5,0.7,0.9,1.0]
n_estimators = [100, 500, 900, 1100, 1500]
max_depth = [2, 3, 5, 10, 15]
min_child_weight = [1,3,5,7]
subsample = [0.6, 0.7, 0.8, 0.9, 1.0]
colsample_bytree = [0.6, 0.7, 0.8, 0.9, 1.0]
reg_lambda = [0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 1.0]
reg_alpha = [0, 0.1, 0.5, 1.0, 1.5]
booster = ['gbtree', 'gblinear']
learning_rate = [0.05, 0.1, 0.15, 0.20]
min_child_weight = [1, 2, 3, 4]

#Define the grid of hyperparameters to search
hyperparameter_grid = {
    'n_estimators' : n_estimators,
    'max_depth': max_depth,
    'learning_rate': learning_rate,
    'min_child_weight': min_child_weight,
    'booster': booster,
    'base_score': base_score
     }
```

In [36]:
```
#Set up the random search with 4-fold cross validation
random_cv = RandomizedSearchCV(estimator=my_model, param_distributions = hyperparameter_grid,
                            cv = 5, n_iter = 50,
                            scoring = 'neg_mean_absolute_error', n_jobs = 4,
                            verbose = 5,
                            return_train_score = True,
                            random_state = 42)
```

In [37]:
```
#fit the model
random_cv.fit(train_X, train_y)
```

```
Fitting 5 folds for each of 50 candidates, totalling 250 fits

[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   25.8s
/opt/conda/lib/python3.7/site-packages/joblib/externals/loky/process_executor.py:706: UserWarning: A worker st
opped while some jobs were given to the executor. This can be caused by a too short worker timeout or by a mem
ory leak.
  "timeout or by a memory leak.", UserWarning
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed:  4.6min
[Parallel(n_jobs=4)]: Done 154 tasks      | elapsed:  7.8min
[Parallel(n_jobs=4)]: Done 250 out of 250 | elapsed: 11.4min finished
```

Out[37]:
```
RandomizedSearchCV(cv=5,
                   estimator=XGBRegressor(base_score=None, booster=None,
                                          colsample_bylevel=None,
                                          colsample_bynode=None,
                                          colsample_bytree=None, gamma=None,
                                          gpu_id=None, importance_type='gain',
                                          interaction_constraints=None,
                                          learning_rate=None,
                                          max_delta_step=None, max_depth=None,
                                          min_child_weight=None, missing=nan,
                                          monotone_constraints=None,
                                          n_estimators=100, n...
                                          validate_parameters=None,
                                          verbosity=None),
                   n_iter=50, n_jobs=4,
                   param_distributions={'base_score': [0.25, 0.5, 0.75, 1],
                                        'booster': ['gbtree', 'gblinear'],
                                        'learning_rate': [0.05, 0.1, 0.15, 0.2],
                                        'max_depth': [2, 3, 5, 10, 15],
                                        'min_child_weight': [1, 2, 3, 4],
                                        'n_estimators': [100, 500, 900, 1100,
                                                         1500]},
                   random_state=42, return_train_score=True,
                   scoring='neg_mean_absolute_error', verbose=5)
```

In [38]:
```
random_cv.best_estimator_
```

Out[38]:
```
XGBRegressor(base_score=1, booster='gbtree', colsample_bylevel=1,
             colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=-1,
             importance_type='gain', interaction_constraints='',
             learning_rate=0.1, max_delta_step=0, max_depth=15,
             min_child_weight=1, missing=nan, monotone_constraints='()',
             n_estimators=900, n_jobs=0, num_parallel_tree=1, random_state=0,
             reg_alpha=0, reg_lambda=1, scale_pos_weight=1, subsample=1,
             tree_method='exact', validate_parameters=1, verbosity=None)
```

In [39]:
```
random_cv.best_params_
```

Out[39]:
```
{'n_estimators': 900,
 'min_child_weight': 1,
 'max_depth': 15,
 'learning_rate': 0.1,
 'booster': 'gbtree',
 'base_score': 1}
```

In [40]:
```
#Apply Grid search to the best parameters from the Random search with a consideration of close values
from sklearn.model_selection import GridSearchCV

param_grid = {
    'booster': [random_cv.best_params_['booster']],
    'max_depth': [random_cv.best_params_['max_depth']],
    'learning_rate': [random_cv.best_params_['learning_rate']],
    'min_child_weight': [random_cv.best_params_['min_child_weight'],
                         random_cv.best_params_['min_child_weight']+2,
                         random_cv.best_params_['min_child_weight'] + 4],
    'base_score': [random_cv.best_params_['base_score'] + 2,
                          random_cv.best_params_['base_score'] +1,
                          random_cv.best_params_['base_score'],
                          random_cv.best_params_['base_score'] +3,
                          random_cv.best_params_['base_score'] + 5],
    'n_estimators': [random_cv.best_params_['n_estimators'] - 200, random_cv.best_params_['n_estimators'] - 100,
                     random_cv.best_params_['n_estimators'],
                     random_cv.best_params_['n_estimators'] + 100, random_cv.best_params_['n_estimators'] + 200]
}

print(param_grid)
```

```
{'booster': ['gbtree'], 'max_depth': [15], 'learning_rate': [0.1], 'min_child_weight': [1, 3, 5], 'base_scor
e': [3, 2, 1, 4, 6], 'n_estimators': [700, 800, 900, 1000, 1100]}
```

In [41]:
```
#### Fit the grid_search to the data
my_model = XGBRegressor()
grid_search=GridSearchCV(estimator=my_model,param_grid=param_grid,cv=10,n_jobs=-1,verbose=2)
grid_search.fit(train_X,train_y)
```

```
Fitting 10 folds for each of 75 candidates, totalling 750 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  33 tasks      | elapsed:  2.9min
[Parallel(n_jobs=-1)]: Done 154 tasks      | elapsed: 24.3min
[Parallel(n_jobs=-1)]: Done 357 tasks      | elapsed: 53.2min
[Parallel(n_jobs=-1)]: Done 640 tasks      | elapsed: 99.0min
[Parallel(n_jobs=-1)]: Done 750 out of 750 | elapsed: 119.6min finished
```

Out[41]:
```
GridSearchCV(cv=10,
             estimator=XGBRegressor(base_score=None, booster=None,
                                    colsample_bylevel=None,
                                    colsample_bynode=None,
                                    colsample_bytree=None, gamma=None,
                                    gpu_id=None, importance_type='gain',
                                    interaction_constraints=None,
                                    learning_rate=None, max_delta_step=None,
                                    max_depth=None, min_child_weight=None,
                                    missing=nan, monotone_constraints=None,
                                    n_estimators=100, n_jobs...
                                    num_parallel_tree=None, random_state=None,
                                    reg_alpha=None, reg_lambda=None,
                                    scale_pos_weight=None, subsample=None,
                                    tree_method=None, validate_parameters=None,
                                    verbosity=None),
             n_jobs=-1,
             param_grid={'base_score': [3, 2, 1, 4, 6], 'booster': ['gbtree'],
                         'learning_rate': [0.1], 'max_depth': [15],
                         'min_child_weight': [1, 3, 5],
                         'n_estimators': [700, 800, 900, 1000, 1100]},
             verbose=2)
```

In [42]:
```
grid_search.best_estimator_
```

Out[42]:
```
XGBRegressor(base_score=4, booster='gbtree', colsample_bylevel=1,
             colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=-1,
             importance_type='gain', interaction_constraints='',
             learning_rate=0.1, max_delta_step=0, max_depth=15,
             min_child_weight=1, missing=nan, monotone_constraints='()',
             n_estimators=700, n_jobs=0, num_parallel_tree=1, random_state=0,
             reg_alpha=0, reg_lambda=1, scale_pos_weight=1, subsample=1,
             tree_method='exact', validate_parameters=1, verbosity=None)
```

In [43]:
```
best_grid=grid_search.best_estimator_
```

In [44]:
```
#The optimal grid search paramaters
best_grid
```

Out[44]:
```
XGBRegressor(base_score=4, booster='gbtree', colsample_bylevel=1,
             colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=-1,
             importance_type='gain', interaction_constraints='',
             learning_rate=0.1, max_delta_step=0, max_depth=15,
             min_child_weight=1, missing=nan, monotone_constraints='()',
             n_estimators=700, n_jobs=0, num_parallel_tree=1, random_state=0,
             reg_alpha=0, reg_lambda=1, scale_pos_weight=1, subsample=1,
             tree_method='exact', validate_parameters=1, verbosity=None)
```

In [45]:
```
#prediction on the validation set
valid_pred = best_grid.predict(valid_X)
```

In [46]:
```
#RMSE score from fitting the model to the validation set
rmse = sqrt(mean_squared_error(valid_y, valid_pred))

print(rmse)
```

```
29.610726652402565
```

In [47]:
```
#Predict stock_distributed from OCT 2019 - DEC 2019
pred = best_grid.predict(test)
```

In [48]:
```
sub['predicted_value']=np.abs(pred)
```

In [49]:
```
#Convert the predicted value to the nearest whole number
sub['predicted_value'] = sub['predicted_value'].round()
```

In [50]:
```
sub.to_csv('Fork of Third_Model.csv', index=False)
```