In [715]:
```
#Importing libraries and data.
import lightgbm as lgb
import numpy as np
import pandas as pd

from matplotlib import pyplot as plt
from pmdarima import auto_arima
from sklearn.metrics import mean_absolute_error, mean_squared_error

df__ = pd.read_csv("C:/Users/Admin/Desktop/dane/wig.csv", parse_dates=["Data"])

#Changing numerical index to Data
df__.set_index("Data", drop=False, inplace=True)
#Viewing types of columns, making sure that Date has a 'datetime' format.
df__.dtypes
```

Out[715]:
```
Data             datetime64[ns]
Otwarcie                float64
Najwyzszy               float64
Najnizszy               float64
Zamkniecie              float64
Wolumen                 float64
dtype: object
```

In [716]:
```
#Changing name of the columns and checking type of data
data = df__.rename(columns=dict(Data='Date', Otwarcie='Open', Najwyzszy='High', Najnizszy='Low', Zamkniecie='Close', Wolumen='Volume'))
data.dtypes
data.describe()
```

Out[716]:

	Open	High	Low	Close	Volume
count	4768.000000	4768.000000	4768.000000	4768.000000	4.765000e+03
mean	41166.127294	41386.653712	40893.372244	41154.325180	5.472219e+07
std	15332.460379	15378.647042	15254.761738	15314.186033	4.777383e+07
min	11539.900000	11650.200000	11464.800000	11564.600000	1.727457e+06
25%	27553.600000	27678.200000	27278.900000	27440.100000	1.754025e+07
50%	44484.120000	44733.385000	44147.535000	44529.495000	4.342025e+07
75%	52909.107500	53118.110000	52663.325000	52886.290000	7.652914e+07
max	67607.050000	67933.050000	67144.100000	67568.500000	6.491139e+08

In [717]:
```
data.columns
```

Out[717]:
```
Index(['Date', 'Open', 'High', 'Low', 'Close', 'Volume'], dtype='object')
```

In [718]:
```
# Creating function, which counts an average price of a day and applying it to an existent dataset.

def VWAP(data):
    v = data.Volume.values
    h = data.High.values
    l = data.Low.values
    return data.assign(VWAP=(v*(h+l)/2)/v)
data = data.groupby(data.index.date, group_keys=False).apply(VWAP)
```

In [719]:
```
#Providing the model information about the time component in the DataFrame.
data.Date = pd.to_datetime(data.Date, format="%Y-%m-%d")
data["month"] = data.Date.dt.month
data["week"] = data.Date.dt.week
data["day"] = data.Date.dt.day
data["day_of_week"] = data.Date.dt.dayofweek
data.head()
```

Out[719]:

Data	Date	Open	High	Low	Close	Volume	VWAP	month	week	day	day_of_week
2020-01-21	2001-01-02	17567.9	17710.2	17486.5	17672.8	4935736.0	17598.35	1	1	2	1
2020-01-21	2001-01-03	17520.7	17676.4	17319.7	17506.1	8818742.0	17498.05	1	1	3	2
2020-01-21	2001-01-04	17673.0	17959.2	17673.0	17875.9	8597278.0	17816.10	1	1	4	3
2020-01-21	2001-01-05	17862.3	17871.4	17508.5	17509.3	8211943.0	17689.95	1	1	5	4
2020-01-21	2001-01-08	17276.7	17276.7	17067.8	17119.3	7374110.0	17172.25	1	2	8	0

In [720]:
```
#Creating variables to use in lagging dataset
data.reset_index(drop=True, inplace=True)
lag_features = ["High", "Low", "Volume"]
window1 = 3
window2 = 7
window3 = 30
data
```

Out[720]:

	Date	Open	High	Low	Close	Volume	VWAP	month	week	day	day_of_week
0	2001-01-02	17567.90	17710.20	17486.50	17672.80	4935736.0	17598.350	1	1	2	1
1	2001-01-03	17520.70	17676.40	17319.70	17506.10	8818742.0	17498.050	1	1	3	2
2	2001-01-04	17673.00	17959.20	17673.00	17875.90	8597278.0	17816.100	1	1	4	3
3	2001-01-05	17862.30	17871.40	17508.50	17509.30	8211943.0	17689.950	1	1	5	4
4	2001-01-08	17276.70	17276.70	17067.80	17119.30	7374110.0	17172.250	1	2	8	0
...	...	...	...	...	...	...	...	...	...	...	...
4763	2020-01-15	59087.67	59162.08	58616.41	58671.25	38504406.0	58889.245	1	3	15	2
4764	2020-01-16	58824.50	58998.65	58718.97	58962.37	43852653.0	58858.810	1	3	16	3
4765	2020-01-17	58893.50	59130.30	58543.53	59039.84	34074400.0	58836.915	1	3	17	4
4766	2020-01-20	59082.18	59214.29	59014.56	59110.06	27949866.0	59114.425	1	4	20	0
4767	2020-01-21	59019.30	59019.39	58572.59	58616.01	33146421.0	58795.990	1	4	21	1

4768 rows × 11 columns

In [721]:
```
#Wrapping lag_features into rolled data. Calculating mean and standard deviation and shifting it over one day.
data_rolled_3d = data[lag_features].rolling(window=window1, min_periods=0)
data_rolled_7d = data[lag_features].rolling(window=window2, min_periods=0)
data_rolled_30d = data[lag_features].rolling(window=window3, min_periods=0)

data_mean_3d = data_rolled_3d.mean().shift(1).reset_index().astype(np.float32)
data_mean_7d = data_rolled_7d.mean().shift(1).reset_index().astype(np.float32)
data_mean_30d = data_rolled_30d.mean().shift(1).reset_index().astype(np.float32)

data_std_3d = data_rolled_3d.std().shift(1).reset_index().astype(np.float32)
data_std_7d = data_rolled_7d.std().shift(1).reset_index().astype(np.float32)
data_std_30d = data_rolled_30d.std().shift(1).reset_index().astype(np.float32)
```

In [722]:
```
#Creating a loop to define exogenous features:
for feature in lag_features:
    data[f"{feature}_mean_lag{window1}"] = data_mean_3d[feature]
    data[f"{feature}_mean_lag{window2}"] = data_mean_7d[feature]
    data[f"{feature}_mean_lag{window3}"] = data_mean_30d[feature]

    data[f"{feature}_std_lag{window1}"] = data_std_3d[feature]
    data[f"{feature}_std_lag{window2}"] = data_std_7d[feature]
    data[f"{feature}_std_lag{window3}"] = data_std_30d[feature]

data.fillna(data.mean(), inplace=True)

data.set_index("Date", drop=False, inplace=True)
```

In [723]:
```
#Splitting the data into train and test dataframe
data_train = data[data.Date < "2019"]
data_test = data[data.Date >= "2019"]
```

In [724]:
```
#
exogenous_features =["Volume_mean_lag3", "Volume_mean_lag7","Volume_mean_lag30", "Volume_std_lag3", "Volume_std_lag7", "Volume_std_lag30",
                     "High_mean_lag3", "High_mean_lag7", "High_mean_lag30", "High_std_lag3", "High_std_lag7", "High_std_lag30",
                     "Low_mean_lag3", "Low_mean_lag7", "Low_mean_lag30", "Low_std_lag3", "Low_std_lag7", "Low_std_lag30",
                     "month", "week", "day", "day_of_week"]
```

In [725]:
```
#Using python library pmdarima to find best fitting ARIMA model to the dataframe with the lowest AIC
model = auto_arima(data_train.VWAP, exogenous=data_train[exogenous_features], trace=True, error_action="ignore", suppress_warnings=True)
model.fit(data_train.VWAP, exogenous=data_train[exogenous_features])
```

```
Fit ARIMA: order=(2, 0, 2) seasonal_order=(0, 0, 0, 1); AIC=70539.623, BIC=70719.198, Fit time=38.691 seconds
Fit ARIMA: order=(0, 0, 0) seasonal_order=(0, 0, 0, 1); AIC=71420.761, BIC=71574.682, Fit time=7.801 seconds
Fit ARIMA: order=(1, 0, 0) seasonal_order=(0, 0, 0, 1); AIC=70678.628, BIC=70838.963, Fit time=20.265 seconds
Fit ARIMA: order=(0, 0, 1) seasonal_order=(0, 0, 0, 1); AIC=71170.776, BIC=71331.111, Fit time=25.260 seconds
Fit ARIMA: order=(1, 0, 2) seasonal_order=(0, 0, 0, 1); AIC=70510.088, BIC=70683.250, Fit time=37.890 seconds
Fit ARIMA: order=(1, 0, 1) seasonal_order=(0, 0, 0, 1); AIC=70660.817, BIC=70827.565, Fit time=28.921 seconds
Fit ARIMA: order=(1, 0, 3) seasonal_order=(0, 0, 0, 1); AIC=70537.958, BIC=70717.533, Fit time=29.297 seconds
Fit ARIMA: order=(2, 0, 3) seasonal_order=(0, 0, 0, 1); AIC=70534.423, BIC=70720.411, Fit time=30.072 seconds
Fit ARIMA: order=(0, 0, 2) seasonal_order=(0, 0, 0, 1); AIC=70498.736, BIC=70665.484, Fit time=13.180 seconds
Fit ARIMA: order=(0, 0, 3) seasonal_order=(0, 0, 0, 1); AIC=70521.479, BIC=70694.640, Fit time=41.957 seconds
Total fit time: 283.355 seconds
```

Out[725]:
```
ARIMA(callback=None, disp=0, maxiter=None, method=None, order=(0, 0, 2),
      out_of_sample_size=0, scoring='mse', scoring_args={},
      seasonal_order=(0, 0, 0, 1), solver='lbfgs', start_params=None,
      suppress_warnings=True, transparams=True, trend=None,
      with_intercept=True)
```

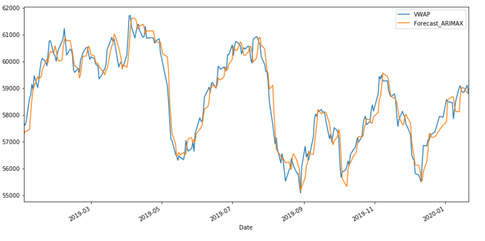
In [726]:
```
#Checking the fit of the model on train dataframe
forecast = model.predict(n_periods=len(data_valid), exogenous=data_test[exogenous_features])
data_test["Forecast_ARIMAX"] = forecast
```

```
C:\Users\Admin\Anaconda3\lib\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: http://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 [727]:
```
#Creating the plot VWAP vs Forecast:
data_test[["VWAP", "Forecast_ARIMAX"]].plot(figsize=(14, 7))
```

Out[727]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1b8386f4708>
```



In [728]:
```
#Root mean square error:
print("RMSE of Auto ARIMAX:", np.sqrt(mean_squared_error(data_test.VWAP, data_test.Forecast_ARIMAX)))
```

```
RMSE of Auto ARIMAX: 432.1856176356221
```

In [729]:
```
#Mean absolute error:
print("MAE of Auto ARIMAX:", mean_absolute_error(data_test.VWAP, data_test.Forecast_ARIMAX))
```

```
MAE of Auto ARIMAX: 347.3987644433007
```

In [730]:
```
len(forecast)
```

Out[730]:
```
261
```