02.01-statistic_models

March 21, 2021

1 Modelos estatísticos

Neste notebook tem os seguintes modelos estatísticos: - AR - ARIMA - SARIMA

1.1 Importações

[29]:

```
# Data analysis and data wrangling
import numpy as np
import pandas as pd

# Metrics
from sklearn.metrics import mean_squared_error

# Plotting
import seaborn as sns
import matplotlib.pyplot as plt

# statsmodels
from statsmodels.tsa.ar_model import AutoReg
from statsmodels.tsa.arima_model import ARIMA
from statsmodels.tsa.statespace.sarimax import SARIMAX
import statsmodels.api as sm

# autoarima
import pmdarima as pm

# Other
from IPython.display import Image
import warnings
import pprint
import datetime
import itertools
import os
```

1.2 Preparação do Diretório Principal

[30]:
```python
def prepare_directory_work(end_directory: str='notebooks'):
    # Current path
    curr_dir = os.path.dirname(os.path.realpath("__file__"))

    if curr_dir.endswith(end_directory):
        os.chdir('..')
        return curr_dir

    return f'Current working directory: {curr_dir}'
```

[31]:
```python
prepare_directory_work(end_directory='notebooks')
```

[31]:
```
'Current working directory: /home/campos/projects/tcc'
```

1.3 Formatação das células

[32]:
```python
# OPTIONAL: Load the "autoreload" extension so that code can change
%load_ext autoreload

# Guarantees visualization inside the jupyter
%matplotlib inline

# Print xxxx rows and columns
pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
pd.set_option('float_format', '{:f}'.format)

# Supress unnecessary warnings so that presentation looks clean
warnings.filterwarnings('ignore')

# pretty print
pp = pprint.PrettyPrinter(indent=4)
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

[33]:
```python
plt.style.use('seaborn')  # fivethirtyeight
plt.rc('figure',figsize=(16,8))
plt.rc('font',size=15)
plt.rc('legend',fontsize=15)

# Seaborn rcParams
# ===================
sns.set(context='poster',  # notebook
        style='darkgrid',
        palette='deep',
        color_codes=True)

# graph style
sns.set(style='dark', palette='deep')

plt.style.use('fivethirtyeight')
```

1.4 Carregamento dos dados

[34]:

```
%%time

df_vale3 = pd.read_csv('data/cleansing/df_vale3_cleansing.csv',
                              encoding='utf8',
                              delimiter=',',
                              parse_dates=True,
                              index_col=0,
                              verbose=True)
```

```
Tokenization took: 2.10 ms
Type conversion took: 2.88 ms
Parser memory cleanup took: 0.01 ms
CPU times: user 14.6 ms, sys: 635 µs, total: 15.2 ms
Wall time: 14 ms
```

[35]:

```
df_vale3.head()
```

[35]:

```
                preco  residuos  tendencia  sazonalidade    diff_1    diff_2  \
data
2010-07-12 40.000000  1.002310  41.827333      1.000149 -0.600000 -0.460000
2010-07-13 40.070000  1.036654  41.910833      0.998563  0.070000 -0.530000
2010-07-14 40.080000  1.028377  41.977833      1.000439  0.010000  0.080000
2010-07-15 39.760000  1.044658  42.045833      1.000935 -0.320000 -0.310000
2010-07-16 38.880000  1.028132  42.123500      1.001784 -0.880000 -1.200000

              diff_3    diff_4    diff_5
data
2010-07-12  0.490000  0.980000  0.420000
2010-07-13 -0.390000  0.560000  1.050000
2010-07-14 -0.520000 -0.380000  0.570000
2010-07-15 -0.240000 -0.840000 -0.700000
2010-07-16 -1.190000 -1.120000 -1.720000
```

1.5 Divisão dos Dados

[36]:
```
size_train = 2415
size_test = 30
print(size_train)
print(size_test)

df_train = df_vale3['preco'].iloc[:size_train]
df_test = df_vale3['preco'].iloc[size_train:]
```

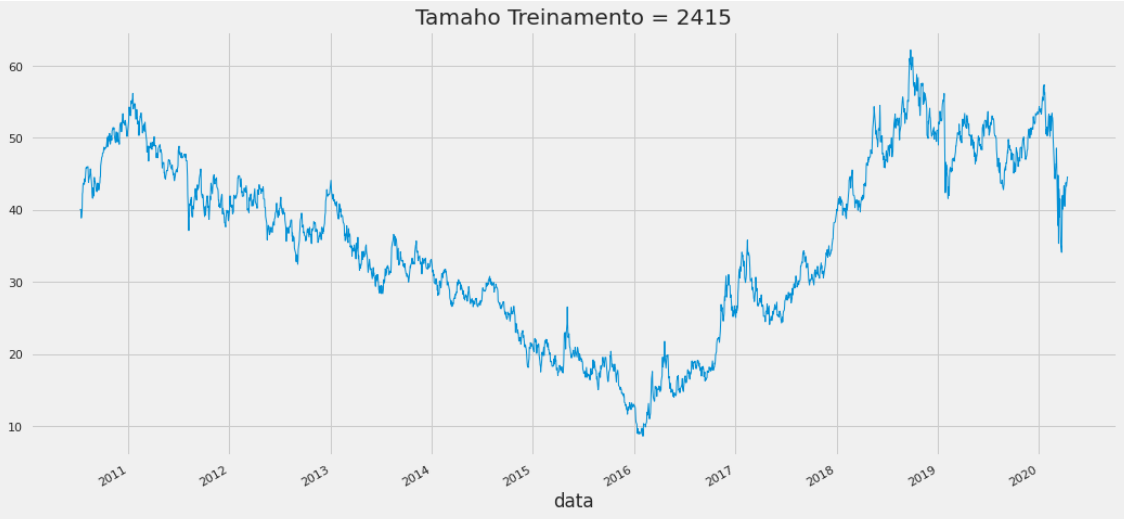
```
2415
30
```

[37]:
```
df_train.tail()
```

[37]:
```
data
2020-04-07    43.780000
2020-04-08    43.510000
2020-04-09    43.280000
2020-04-13    44.570000
2020-04-14    44.530000
Name: preco, dtype: float64
```

[38]:
```
df_train.plot(linewidth=1)
plt.grid(True)
plt.title(f'Tamaho Treinamento = {len(df_train)}')
```

[38]:
```
Text(0.5, 1.0, 'Tamaho Treinamento = 2415')
```

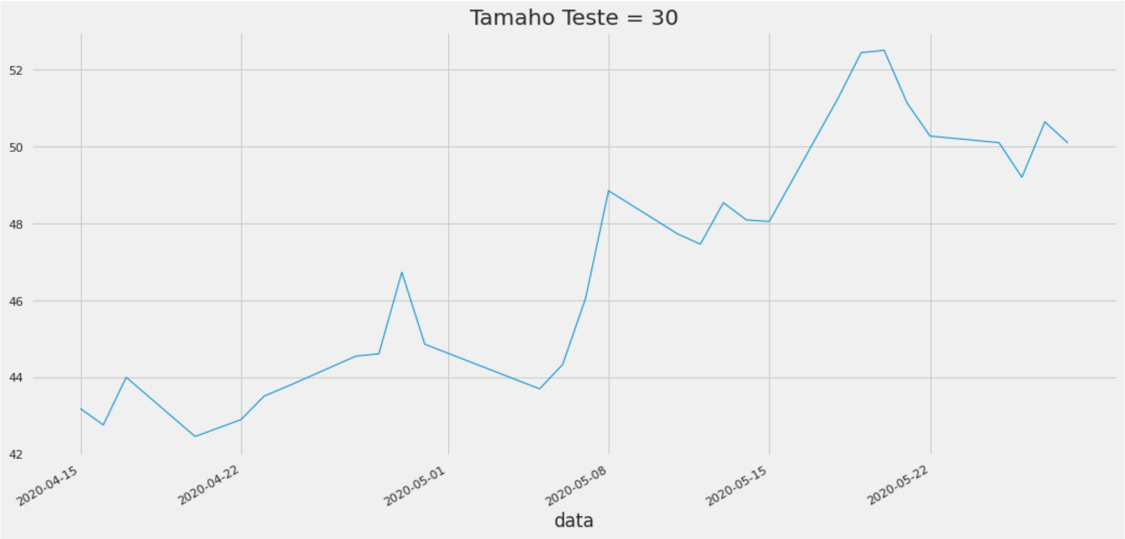


[39]:
```
df_test.head()
```

```
[39]: data
      2020-04-15    43.190000
      2020-04-16    42.760000
      2020-04-17    44.000000
      2020-04-20    42.460000
      2020-04-22    42.900000
      Name: preco, dtype: float64
```

```
[40]: df_test.plot(linewidth=1)
      plt.grid(True)
      plt.title(f'Tamaho Teste = {len(df_test)}')
```

```
[40]: Text(0.5, 1.0, 'Tamaho Teste = 30')
```



1.5.1 Manipulação do índice

```
[41]: df_train.index
```

```
[41]: DatetimeIndex(['2010-07-12', '2010-07-13', '2010-07-14', '2010-07-15',
                     '2010-07-16', '2010-07-19', '2010-07-20', '2010-07-21',
                     '2010-07-22', '2010-07-23',
                     …
                     '2020-03-31', '2020-04-01', '2020-04-02', '2020-04-03',
                     '2020-04-06', '2020-04-07', '2020-04-08', '2020-04-09',
                     '2020-04-13', '2020-04-14'],
                    dtype='datetime64[ns]', name='data', length=2415, freq=None)
```

```
[42]: df_test.index
```

```
[42]: DatetimeIndex(['2020-04-15', '2020-04-16', '2020-04-17', '2020-04-20',
                     '2020-04-22', '2020-04-23', '2020-04-24', '2020-04-27',
                     '2020-04-28', '2020-04-29', '2020-04-30', '2020-05-04',
                     '2020-05-05', '2020-05-06', '2020-05-07', '2020-05-08',
                     '2020-05-11', '2020-05-12', '2020-05-13', '2020-05-14',
                     '2020-05-15', '2020-05-18', '2020-05-19', '2020-05-20',
                     '2020-05-21', '2020-05-22', '2020-05-25', '2020-05-26',
                     '2020-05-27', '2020-05-28'],
                    dtype='datetime64[ns]', name='data', freq=None)
```

```
[43]: df_train.reset_index(drop=True, inplace=True)
      df_train.index
```

```
[43]: RangeIndex(start=0, stop=2415, step=1)
```

```
[44]: df_test.reset_index(drop=True, inplace=True)
      df_test.index
```

```
[44]: RangeIndex(start=0, stop=30, step=1)
```

```
[45]: df_train.index = pd.RangeIndex(start=0, stop=len(df_train), step=1)
      df_train.index
```

```
[45]: RangeIndex(start=0, stop=2415, step=1)
```

```
[46]: df_test.index = pd.RangeIndex(start=2415, stop=len(df_vale3), step=1)
      df_test.index
```

```
[46]: RangeIndex(start=2415, stop=2445, step=1)
```

1.6 Métrica de Avaliação

```
[47]: def mean_absolute_percentage_error(y_true, y_pred):
          y_true, y_pred = np.array(y_true), np.array(y_pred)
          return np.mean(np.abs((y_true - y_pred) / y_true)) * 100
```

1.7 Dicionário de Resultados

```
[48]: dict_results = {}
```

1.8 Impressão dos Resutados

[49]:

```
def show_result_model(df_train, df_test, y_forecast, model_name):
    future_forecast = pd.DataFrame(y_forecast,
                                   index=df_test.index,
                                   columns=['previsao'])
    mape = mean_absolute_percentage_error(df_test, y_forecast)
    mse = mean_squared_error(df_test, y_forecast, squared=True)
    dict_results[model_name] = [mape, mse]

    pd.concat([df_test, future_forecast], axis=1).plot()

    plt.legend()
    plt.grid(True)
    plt.xlabel("Tempo (dias)", fontsize=20)
    plt.ylabel("Preço (R$)", fontsize=20)
    plt.title(f'MAPE = {mape:.2f} % | MSE = {mse:.2f}', fontsize=25)
```

1.9 Busca dos Melhores Parâmetros

Grid Search

[50]:

```
# Define the p, d and q parameters to take any value between 0 and 2
p = q = range(0, 3)
d = range(0, 3)

# Generate all different combinations of p, q and q triplets
list_pdq = list(itertools.product(p, d, q))
print(f'All different combinations of p, q and q:\n {list_pdq}')

# Generate all different combinations of seasonal p, q and q triplets
seasonal_pdq = [(x[0], x[1], x[2], 12) for x in list(itertools.product(p, d,␣
 ↪q))]
print(f'\n\nAll different combinations of seasonal p, q and q:\n␣
 ↪{seasonal_pdq}')
```

```
All different combinations of p, q and q:
 [(0, 0, 0), (0, 0, 1), (0, 0, 2), (0, 1, 0), (0, 1, 1), (0, 1, 2), (0, 2, 0),
(0, 2, 1), (0, 2, 2), (1, 0, 0), (1, 0, 1), (1, 0, 2), (1, 1, 0), (1, 1, 1), (1,
1, 2), (1, 2, 0), (1, 2, 1), (1, 2, 2), (2, 0, 0), (2, 0, 1), (2, 0, 2), (2, 1,
0), (2, 1, 1), (2, 1, 2), (2, 2, 0), (2, 2, 1), (2, 2, 2)]


All different combinations of seasonal p, q and q:
 [(0, 0, 0, 12), (0, 0, 1, 12), (0, 0, 2, 12), (0, 1, 0, 12), (0, 1, 1, 12), (0,
1, 2, 12), (0, 2, 0, 12), (0, 2, 1, 12), (0, 2, 2, 12), (1, 0, 0, 12), (1, 0, 1,
12), (1, 0, 2, 12), (1, 1, 0, 12), (1, 1, 1, 12), (1, 1, 2, 12), (1, 2, 0, 12),
(1, 2, 1, 12), (1, 2, 2, 12), (2, 0, 0, 12), (2, 0, 1, 12), (2, 0, 2, 12), (2,
1, 0, 12), (2, 1, 1, 12), (2, 1, 2, 12), (2, 2, 0, 12), (2, 2, 1, 12), (2, 2, 2,
12)]
```

[51]:

```python
def search_best_params_arima_model(df_train: 'Dataframe', pdq: list) -> list:
    best_model = 99999
    best_params = (0, 0, 0)
    param = ()

    for param in pdq:
        try:
            arima_model = ARIMA(df_train, order=param)
            results = arima_model.fit()
            print(f'pdq = {param} | AIC = {results.aic}')

            if results.aic < best_model:
                best_model = results.aic
                best_params = param
        except:
            continue

    print(f'best ARIMA: {best_params} | AIC:{best_model}')
    return [best_params, best_model]
```

[52]:

```python
def search_best_params_sarima_model(df_train, trend, pdq):
    best_model = 99999
    best_param_seasonal = ()
    param = ()
    param_seasonal = ()

    for param_seasonal in seasonal_pdq:
        try:
            sarima_model = SARIMAX(df_train,
                                   order=pdq,
                                   seasonal_order=param_seasonal,
                                   trend=trend,
                                   enforce_stationarity=True,
                                   enforce_invertibility=False)
            results = sarima_model.fit()
            print(f'pdq = {pdq} | param_seasonal = {param_seasonal} | AIC =␣
 ↪{results.aic}')

            if results.aic < best_model:
                best_model = results.aic
                best_param_seasonal = param_seasonal
        except:
            continue
    print(f'\n\nBest SARIMA: {pdq}x{param_seasonal}12 | AIC:{best_model}')
    return [best_param_seasonal, best_model]
```

1.10 Modelos Estatísticos

1.11 AR

- A ST não é estacionária
- Não há tendência, (trend='n')
- Não aá sazonalidade, (seasonal=False) no período de 30 dias

[53]:

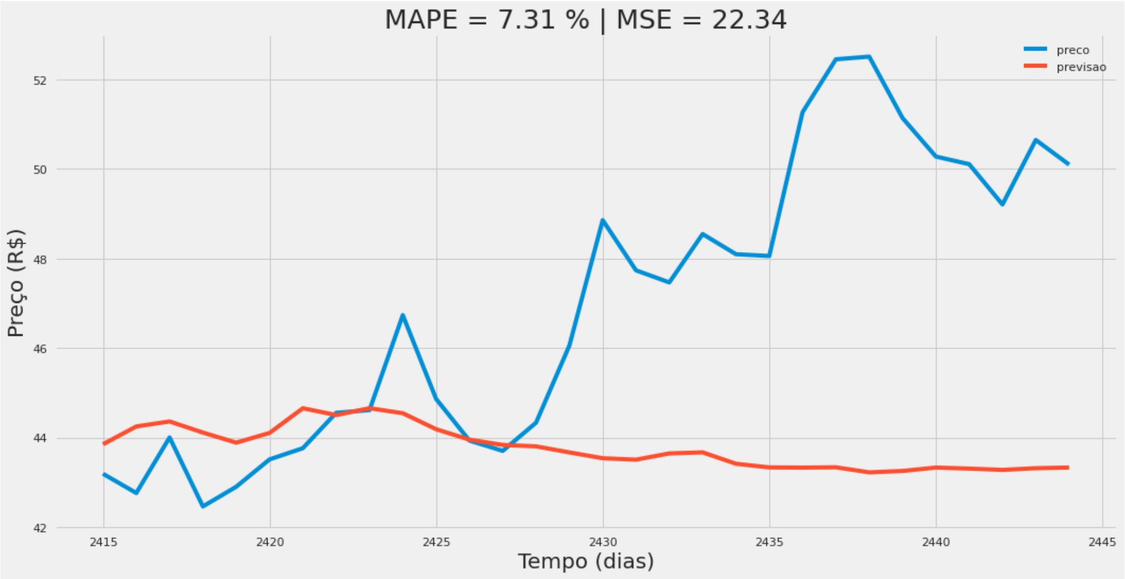
```
ar_model = AutoReg(df_train,
                   lags=30,
                   trend='n',
                   seasonal=False,
                   period=len(df_test))
ar_fit = ar_model.fit()
```

[54]:

```
# forecast
y_ar_forecast = ar_fit.predict(start=(df_test.index[0]), end=df_test.index[-1])
```

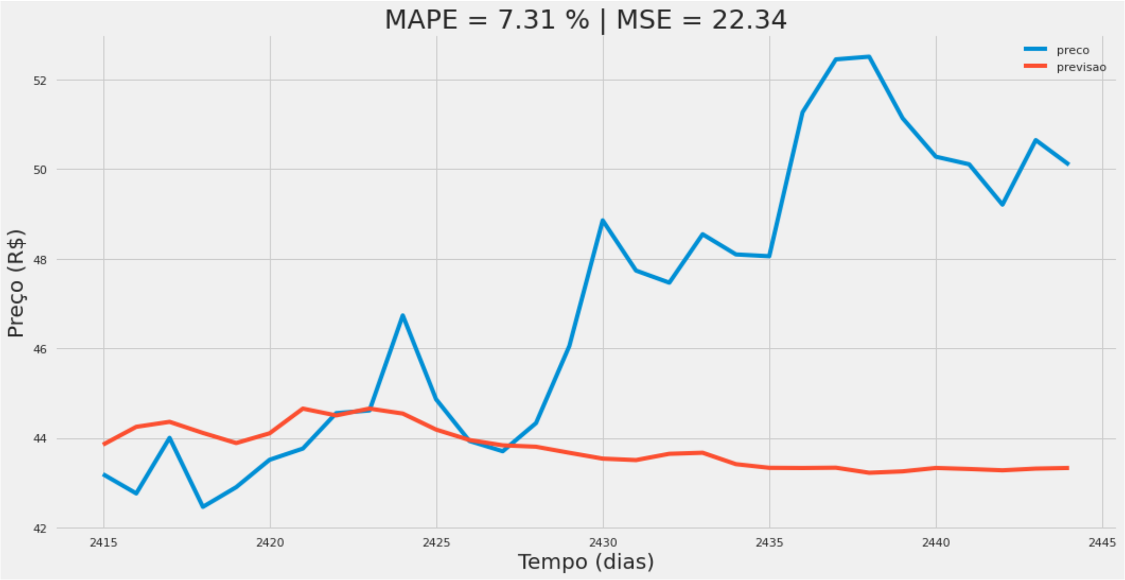
[55]:

```
show_result_model(df_train=df_train,
                  df_test=df_test,
                  y_forecast=y_ar_forecast,
                  model_name='ar_model')
```



zoom

[56]:
```
show_result_model(df_train=df_test,
                  df_test=df_test,
                  y_forecast=y_ar_forecast,
                  model_name='ar_model')
```



1.11.1 ARIMA

1.12 Librarie: `pmdarima`

- Tips: https://alkaline-ml.com/pmdarima/tips_and_tricks.html

[57]:
```
%%time

list_order_arima = search_best_params_arima_model(df_train=df_train,
                                                  pdq=list_pdq)
print(list_order_arima)
```

```
pdq = (0, 0, 0) | AIC = 18974.159932736322
pdq = (0, 0, 1) | AIC = 15847.637275064231
pdq = (0, 0, 2) | AIC = 13561.154466403974
pdq = (0, 1, 0) | AIC = 6352.768252799672
pdq = (0, 1, 1) | AIC = 6350.524624394297
pdq = (0, 1, 2) | AIC = 6340.313542113301
pdq = (0, 2, 0) | AIC = 8115.886934606986
pdq = (0, 2, 1) | AIC = 6360.642759046002
pdq = (0, 2, 2) | AIC = 6359.287622193227
pdq = (1, 0, 0) | AIC = 6358.62505633127
pdq = (1, 0, 1) | AIC = 6356.660857064225
pdq = (1, 0, 2) | AIC = 6346.8611580606375
pdq = (1, 1, 0) | AIC = 6351.105797529564
pdq = (1, 1, 1) | AIC = 6343.033761417953
pdq = (1, 1, 2) | AIC = 6336.2914261760225
pdq = (1, 2, 0) | AIC = 7467.9662234387815
pdq = (1, 2, 1) | AIC = 6359.034728262
pdq = (2, 0, 0) | AIC = 6357.196557476122
pdq = (2, 0, 1) | AIC = 6349.8852699168365
pdq = (2, 0, 2) | AIC = 6342.645188065021
pdq = (2, 1, 0) | AIC = 6341.3047553815495
pdq = (2, 1, 1) | AIC = 6337.075186435318
pdq = (2, 2, 0) | AIC = 7092.466407612979
pdq = (2, 2, 1) | AIC = 6349.331988280079
pdq = (2, 2, 2) | AIC = 6345.944394704168
best ARIMA: (1, 1, 2) | AIC:6336.2914261760225
[(1, 1, 2), 6336.2914261760225]
CPU times: user 22.8 s, sys: 11.8 s, total: 34.5 s
Wall time: 12.8 s
```

[58]:

```
%%time

autoarima_model = pm.auto_arima(df_train,
                                stepwise=True,
                                suppress_warnings=True,
                                error_action="ignore",
                                information_criterion='aic',
                                start_p=1,
                                start_d=1,
                                start_q=2,
                                max_p=30,
                                max_d=30,
                                max_q=30,
                                # trend=False,
                                seasonal=False,
                                trace=True)
```

```
Performing stepwise search to minimize aic
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=6336.291, Time=0.89 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=6352.768, Time=0.84 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=6351.106, Time=0.13 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=6350.525, Time=0.20 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=6350.779, Time=0.05 sec
 ARIMA(0,1,2)(0,0,0)[0] intercept   : AIC=6340.314, Time=0.29 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=6343.034, Time=0.84 sec
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=6335.575, Time=2.29 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=6337.075, Time=1.47 sec
 ARIMA(3,1,2)(0,0,0)[0] intercept   : AIC=6336.166, Time=1.74 sec
 ARIMA(2,1,3)(0,0,0)[0] intercept   : AIC=6334.093, Time=3.54 sec
 ARIMA(1,1,3)(0,0,0)[0] intercept   : AIC=6337.673, Time=1.21 sec
 ARIMA(3,1,3)(0,0,0)[0] intercept   : AIC=6336.181, Time=2.87 sec
 ARIMA(2,1,4)(0,0,0)[0] intercept   : AIC=6337.758, Time=4.31 sec
 ARIMA(1,1,4)(0,0,0)[0] intercept   : AIC=6336.944, Time=1.93 sec
 ARIMA(3,1,4)(0,0,0)[0] intercept   : AIC=6321.479, Time=5.36 sec
 ARIMA(4,1,4)(0,0,0)[0] intercept   : AIC=6325.029, Time=5.96 sec
 ARIMA(3,1,5)(0,0,0)[0] intercept   : AIC=6323.272, Time=12.73 sec
 ARIMA(2,1,5)(0,0,0)[0] intercept   : AIC=6339.721, Time=8.50 sec
 ARIMA(4,1,3)(0,0,0)[0] intercept   : AIC=6336.502, Time=4.15 sec
 ARIMA(4,1,5)(0,0,0)[0] intercept   : AIC=6323.836, Time=13.31 sec
 ARIMA(3,1,4)(0,0,0)[0]             : AIC=6319.397, Time=3.36 sec
 ARIMA(2,1,4)(0,0,0)[0]             : AIC=6335.771, Time=1.87 sec
 ARIMA(3,1,3)(0,0,0)[0]             : AIC=6334.044, Time=1.90 sec
 ARIMA(4,1,4)(0,0,0)[0]             : AIC=6322.980, Time=4.12 sec
 ARIMA(3,1,5)(0,0,0)[0]             : AIC=6321.422, Time=5.42 sec
 ARIMA(2,1,3)(0,0,0)[0]             : AIC=6332.106, Time=0.84 sec
 ARIMA(2,1,5)(0,0,0)[0]             : AIC=6337.734, Time=10.79 sec
 ARIMA(4,1,3)(0,0,0)[0]             : AIC=6334.328, Time=2.35 sec
 ARIMA(4,1,5)(0,0,0)[0]             : AIC=6321.854, Time=2.45 sec

Best model:  ARIMA(3,1,4)(0,0,0)[0]
Total fit time: 105.743 seconds
CPU times: user 5min 39s, sys: 3min 18s, total: 8min 58s
Wall time: 1min 45s
```

[59]:

```
print(autoarima_model.order)
print(autoarima_model.aic())
```

```
(3, 1, 4)
6319.39685000518
```

[60]:

```
# fit
autoarima_model_fit = autoarima_model.fit(y=df_train)
autoarima_model_fit
```

[60]:

```
ARIMA(order=(3, 1, 4), scoring_args={}, suppress_warnings=True,
      with_intercept=False)
```

[61]:

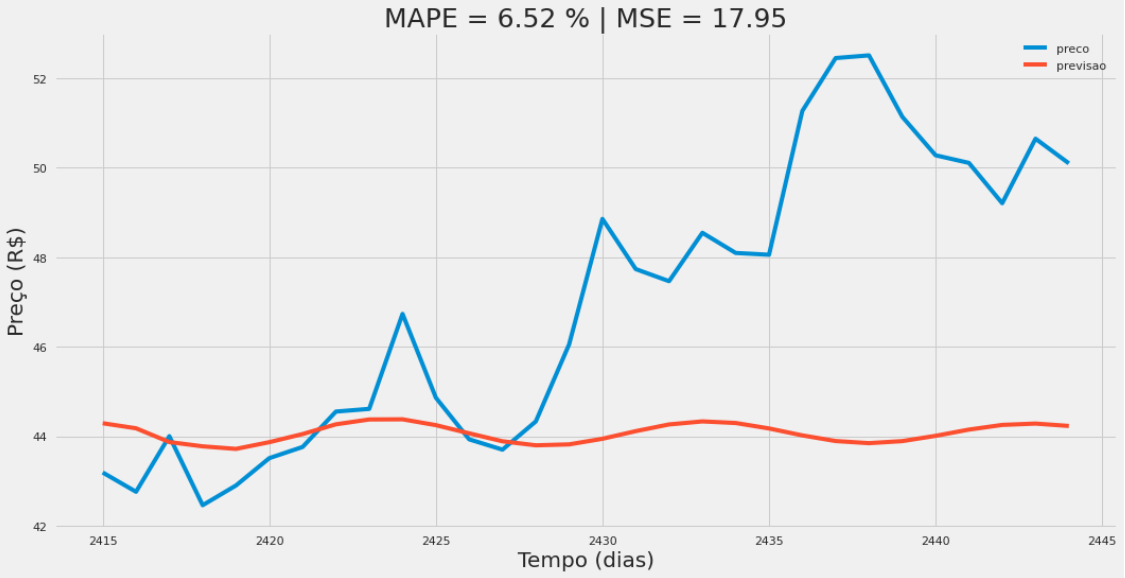
```
# forecast
y_forecast = autoarima_model_fit.predict(n_periods=len(df_test[:50]))
len(y_forecast)
```

[61]:

```
30
```

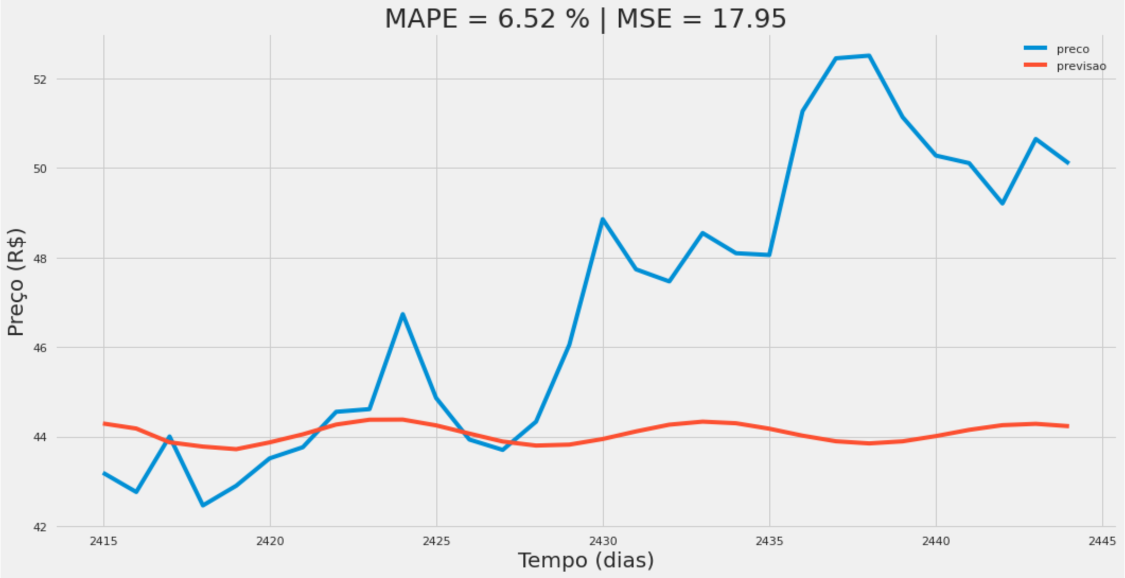
[62]:

```
show_result_model(df_train=df_train,
                  df_test=df_test,
                  y_forecast=y_forecast,
                  model_name='arima_model')
```



Zoom

[63]:
```
show_result_model(df_train=df_test,
                  df_test=df_test,
                  y_forecast=y_forecast,
                  model_name='arima_model')
```



1.13 SARIMA

[64]:

```
%%time

list_order_seasonal_aic = search_best_params_sarima_model(df_train=df_train,
                                                          trend='t',
                                                          pdq=(3, 1, 3))

print(list_order_seasonal_aic)
```

```
pdq = (3, 1, 3) | param_seasonal = (0, 0, 0, 12) | AIC = 6339.124621859275
pdq = (3, 1, 3) | param_seasonal = (0, 0, 1, 12) | AIC = 6338.031419311456
pdq = (3, 1, 3) | param_seasonal = (0, 0, 2, 12) | AIC = 6336.018124144093
pdq = (3, 1, 3) | param_seasonal = (0, 1, 0, 12) | AIC = 8059.09988429914
pdq = (3, 1, 3) | param_seasonal = (0, 1, 1, 12) | AIC = 7004.804412774307
pdq = (3, 1, 3) | param_seasonal = (0, 1, 2, 12) | AIC = 6912.811466815344
pdq = (3, 1, 3) | param_seasonal = (0, 2, 0, 12) | AIC = 10631.931835186979
pdq = (3, 1, 3) | param_seasonal = (0, 2, 1, 12) | AIC = 9840.03632141267
pdq = (3, 1, 3) | param_seasonal = (0, 2, 2, 12) | AIC = 8910.811939479154
pdq = (3, 1, 3) | param_seasonal = (1, 0, 0, 12) | AIC = 6338.128198280105
pdq = (3, 1, 3) | param_seasonal = (1, 0, 1, 12) | AIC = 6335.981000287489
pdq = (3, 1, 3) | param_seasonal = (1, 0, 2, 12) | AIC = 6336.456711085466
pdq = (3, 1, 3) | param_seasonal = (1, 1, 0, 12) | AIC = 7440.089436402188
pdq = (3, 1, 3) | param_seasonal = (1, 1, 1, 12) | AIC = 7021.478686571869
pdq = (3, 1, 3) | param_seasonal = (1, 1, 2, 12) | AIC = 6919.713727034271
pdq = (3, 1, 3) | param_seasonal = (1, 2, 0, 12) | AIC = 9539.404449558362
pdq = (3, 1, 3) | param_seasonal = (1, 2, 1, 12) | AIC = 8963.305012269524
pdq = (3, 1, 3) | param_seasonal = (1, 2, 2, 12) | AIC = 9679.523799182765
pdq = (3, 1, 3) | param_seasonal = (2, 0, 0, 12) | AIC = 6336.465787506138
pdq = (3, 1, 3) | param_seasonal = (2, 0, 1, 12) | AIC = 6335.857132528785
pdq = (3, 1, 3) | param_seasonal = (2, 0, 2, 12) | AIC = 6338.7335421307
pdq = (3, 1, 3) | param_seasonal = (2, 1, 0, 12) | AIC = 7250.051289167632
pdq = (3, 1, 3) | param_seasonal = (2, 1, 1, 12) | AIC = 7037.807659090762
pdq = (3, 1, 3) | param_seasonal = (2, 1, 2, 12) | AIC = 6919.0597162293125
pdq = (3, 1, 3) | param_seasonal = (2, 2, 0, 12) | AIC = 9235.612146737145
pdq = (3, 1, 3) | param_seasonal = (2, 2, 1, 12) | AIC = 8983.171488430893
pdq = (3, 1, 3) | param_seasonal = (2, 2, 2, 12) | AIC = 9260.152640966668


Best SARIMA: (3, 1, 3)x(2, 2, 2, 12)12 | AIC:6335.857132528785
[(2, 0, 1, 12), 6335.857132528785]
CPU times: user 1h 32min 33s, sys: 1h 5min 34s, total: 2h 38min 8s
Wall time: 29min 54s
```

[65]:

```
list_order_seasonal_aic
```

[65]:

```
[(2, 0, 1, 12), 6335.857132528785]
```

[66]:

```
# autosarima_model = pm.auto_arima(df_train,
#                                  stepwise=True,
#                                  suppress_warnings=True,
#                                  error_action="ignore",
#                                  information_criterion='aic',
#                                  start_p=3,
#                                  start_d=1,
#                                  start_q=3,
#                                  max_p=30,
#                                  max_d=30,
#                                  max_q=30,
#                                  seasonal=True,
#                                  stationary=False,
#                                  trace=True)
```

[67]:

```
sarima_model = SARIMAX(df_train,
                       order=(6, 2, 6),
                       seasonal_order=list_order_seasonal_aic[0],
                       trend='c',
                       enforce_stationarity=False,
                       enforce_invertibility=False)
```

[68]:

```
# fit
sarima_fit = sarima_model.fit()
print(sarima_fit)
```

```
<statsmodels.tsa.statespace.sarimax.SARIMAXResultsWrapper object at
0x7fe7585edac0>
```

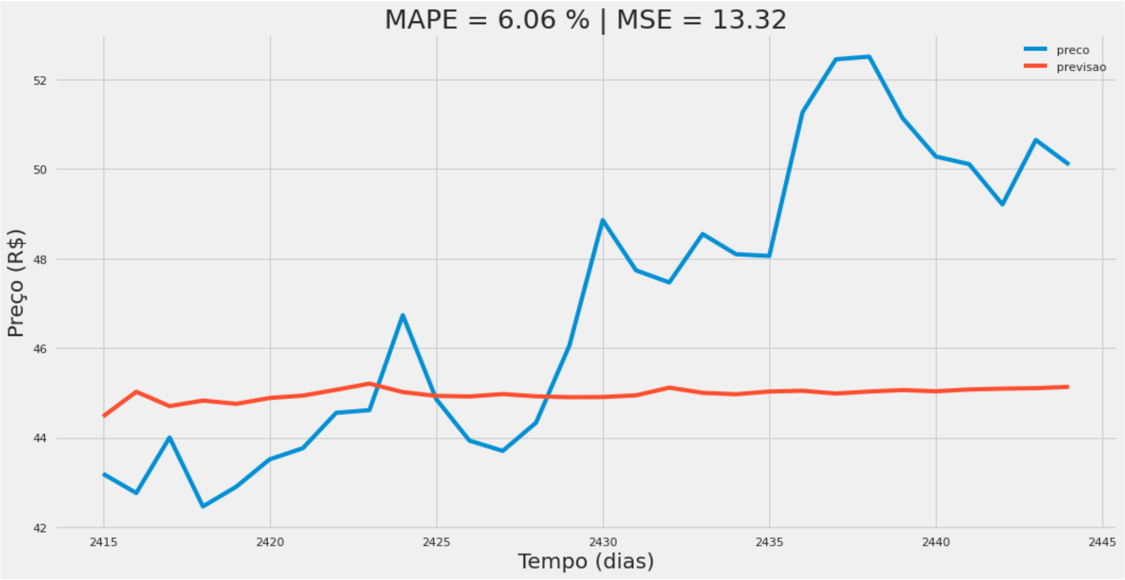
[69]:

```
# forecast
y_forecast_sarima = sarima_fit.predict(start=df_test.index[0], end=df_test.
 ↪index[-1])
print(len(y_forecast_sarima))
```

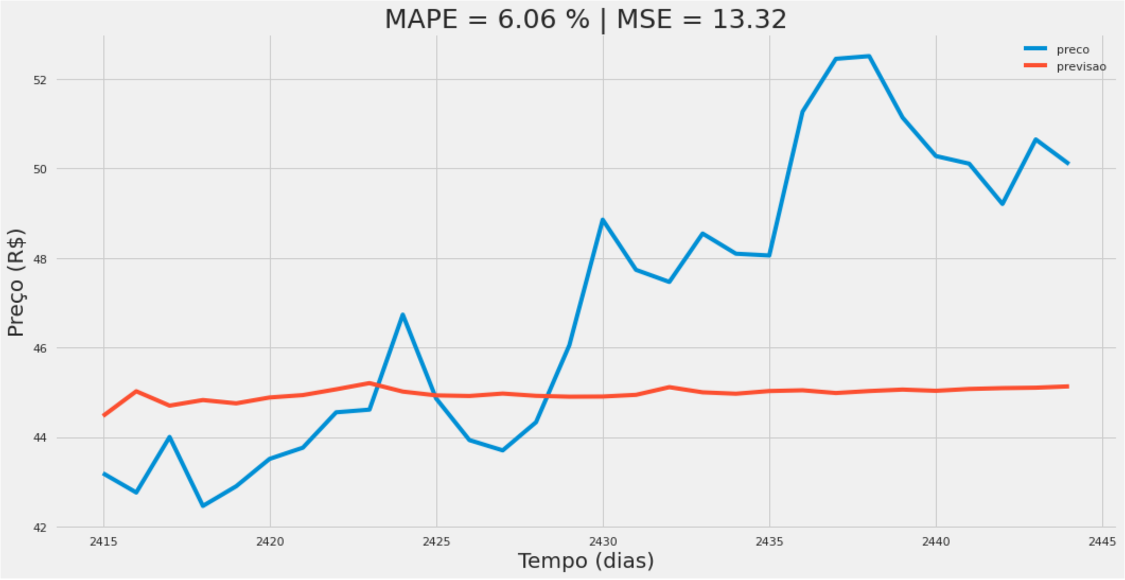
```
30
```

[70]:

```
show_result_model(df_train=df_train,
                  df_test=df_test,
                  y_forecast=y_forecast_sarima,
                  model_name='sarima_model')
```



```
[71]: show_result_model(df_train=df_test,
                        df_test=df_test,
                        y_forecast=y_forecast_sarima,
                        model_name='sarima_model')
```



1.14 Resultados

```
[72]: dict_results
```

```
[72]: {'ar_model': [7.305621439008979, 22.343211526143307],
       'arima_model': [6.523541924668703, 17.950380032175307],
       'sarima_model': [6.063893351025526, 13.322516952460289]}
```