In [218…

```
# 1 - BIBLIOTECAS e PACOTES

import numpy as np
import seaborn as sns
import pandas as pd
from pandas import DataFrame
from pandas.util.testing import assert_frame_equal
from pandas_datareader import data
import matplotlib.pyplot as plt
import datetime
import math
```

In [219…

```
from scipy import stats
```

In [220…

```
import plotly.express as px
import plotly.figure_factory as ff
from copy import copy
```

In [221…

```
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
```

In [222…

```
import sklearn.metrics
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
```

In [223…

```
from tensorflow import keras
```

In [224…

```
# 2 - PROCESSAMENTO/TRATAMENTO DOS DADOS
```

In [225…

```
milho_df = pd.read_excel('Milho-CEPEA-ESALQ.xlsx')
milho_df
```

Out[225…

	INDICADOR DO MILHO ESALQ/BM&FBOVESPA	Unnamed: 1	Unnamed: 2	Unnamed: 3	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unna
0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
1	Fonte: Cepea	NaN	NaN	NaN	NaN	NaN	NaN	
2	Data	À vista R$	À vista US$	NaN	NaN	NaN	NaN	
3	02/08/2004	18.24	5.98	NaN	NaN	NaN	NaN	
4	03/08/2004	18.04	5.91	NaN	NaN	NaN	NaN	
...	...	...	...	...	...	...	...	
4125	25/02/2021	85.59	15.55	NaN	NaN	NaN	NaN	
4126	26/02/2021	85.41	15.3	NaN	NaN	NaN	NaN	
4127	01/03/2021	85.59	15.29	NaN	NaN	NaN	NaN	
4128	02/03/2021	86.11	15.2	NaN	NaN	NaN	NaN	
4129	03/03/2021	87.06	15.14	NaN	NaN	NaN	NaN	

4130 rows × 10 columns

In [226…

```
milho_df = milho_df.drop(milho_df.index[0:3])
milho_df = milho_df.drop(columns=milho_df.columns[3:])
milho_df
```

Out[226…

	INDICADOR DO MILHO ESALQ/BM&FBOVESPA	Unnamed: 1	Unnamed: 2
3	02/08/2004	18.24	5.98
4	03/08/2004	18.04	5.91
5	04/08/2004	18.02	5.9
6	05/08/2004	18.06	5.89
7	06/08/2004	18.13	5.98
...	...	...	...
4125	25/02/2021	85.59	15.55
4126	26/02/2021	85.41	15.3
4127	01/03/2021	85.59	15.29
4128	02/03/2021	86.11	15.2
4129	03/03/2021	87.06	15.14

4127 rows × 3 columns

In [227…

```
milho_df.rename(columns= {'INDICADOR DO MILHO ESALQ/BM&FBOVESPA': 'Data'}, inplace=True
milho_df.rename(columns= {'Unnamed: 1': 'milho_reais'}, inplace=True)
milho_df.rename(columns= {'Unnamed: 2': 'milho_dolares'}, inplace=True)
milho_df
```

Out[227…

	Data	milho_reais	milho_dolares
3	02/08/2004	18.24	5.98
4	03/08/2004	18.04	5.91
5	04/08/2004	18.02	5.9
6	05/08/2004	18.06	5.89
7	06/08/2004	18.13	5.98
...	...	...	...
4125	25/02/2021	85.59	15.55
4126	26/02/2021	85.41	15.3
4127	01/03/2021	85.59	15.29
4128	02/03/2021	86.11	15.2
4129	03/03/2021	87.06	15.14

4127 rows × 3 columns

In [228…

```
milho_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 4127 entries, 3 to 4129
Data columns (total 3 columns):
 #   Column         Non-Null Count  Dtype 
---  ------         --------------  ----- 
 0   Data           4127 non-null   object
 1   milho_reais    4127 non-null   object
 2   milho_dolares  4127 non-null   object
dtypes: object(3)
memory usage: 129.0+ KB
```

In [229…

```
milho_df['milho_reais'] = milho_df['milho_reais'].astype(float)
milho_df['milho_dolares'] = milho_df['milho_dolares'].astype(float)
milho_df
```

Out[229…

	Data	milho_reais	milho_dolares
3	02/08/2004	18.24	5.98
4	03/08/2004	18.04	5.91
5	04/08/2004	18.02	5.90
6	05/08/2004	18.06	5.89
7	06/08/2004	18.13	5.98
...	...	...	...
4125	25/02/2021	85.59	15.55
4126	26/02/2021	85.41	15.30
4127	01/03/2021	85.59	15.29
4128	02/03/2021	86.11	15.20
4129	03/03/2021	87.06	15.14

4127 rows × 3 columns

In [230…

```
milho_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 4127 entries, 3 to 4129
Data columns (total 3 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   Data           4127 non-null   object 
 1   milho_reais    4127 non-null   float64
 2   milho_dolares  4127 non-null   float64
dtypes: float64(2), object(1)
memory usage: 129.0+ KB
```

In [231…

```
milho_df['Data']
```

Out[231…

```
3       02/08/2004
4       03/08/2004
5       04/08/2004
6       05/08/2004
7       06/08/2004
           ...
```

```
4125    25/02/2021
4126    26/02/2021
4127    01/03/2021
4128    02/03/2021
4129    03/03/2021
Name: Data, Length: 4127, dtype: object
```

In [232…

```
milho_df['Data'] = pd.to_datetime(milho_df['Data'],dayfirst=True)
milho_df = milho_df.sort_values(by = ['Data'])
milho_df['Data']
```

Out[232…

```
3      2004-08-02
4      2004-08-03
5      2004-08-04
6      2004-08-05
7      2004-08-06
          ...
4125   2021-02-25
4126   2021-02-26
4127   2021-03-01
4128   2021-03-02
4129   2021-03-03
Name: Data, Length: 4127, dtype: datetime64[ns]
```

In [233…

```
milho_df.index
```

Out[233…

```
Int64Index([   3,    4,    5,    6,    7,    8,    9,   10,   11,   12,
            ...
            4120, 4121, 4122, 4123, 4124, 4125, 4126, 4127, 4128, 4129],
           dtype='int64', length=4127)
```

In [234…

```
milho_df.index = pd.to_datetime(milho_df.Data)
milho_df.index.to_period('D')
milho_df.index
```

Out[234…

```
DatetimeIndex(['2004-08-02', '2004-08-03', '2004-08-04', '2004-08-05',
               '2004-08-06', '2004-08-09', '2004-08-10', '2004-08-11',
               '2004-08-12', '2004-08-13',
               ...
               '2021-02-18', '2021-02-19', '2021-02-22', '2021-02-23',
               '2021-02-24', '2021-02-25', '2021-02-26', '2021-03-01',
               '2021-03-02', '2021-03-03'],
              dtype='datetime64[ns]', name='Data', length=4127, freq=None)
```

In [235…

```
milho_df.isnull().sum()
```

Out[235…

```
Data            0
milho_reais     0
milho_dolares   0
dtype: int64
```

In [236…

```
ccmfut_df = pd.read_excel('CCMFUT-ProfitChart.xlsx')
ccmfut_df
```

Out[236…

	Data	Abertura	Máxima	Mínima	Fechamento	Volume Financeiro
0	2021-03-05	94.10	96.46	94.10	95.85	380377381.5
1	2021-03-04	91.00	94.72	90.40	94.20	325967202.0
2	2021-03-03	89.00	91.10	88.86	91.05	211768164.0
3	2021-03-02	88.80	89.06	88.54	88.94	95795617.5

	Data	Abertura	Máxima	Mínima	Fechamento	Volume Financeiro
4	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
...	...	...	...	...	...	...
2914	2008-10-02	22.64	22.64	22.64	22.64	11295.0
2915	2008-09-30	22.55	22.55	22.55	22.55	112500.0
2916	2008-09-26	22.68	22.68	22.68	22.68	565875.0
2917	2008-09-22	22.64	22.64	22.64	22.64	112950.0
2918	2008-09-19	22.64	22.64	22.64	22.64	1129500.0

2919 rows × 6 columns

In [237…

```
ccmfut_df.rename(columns= {'Abertura': 'ccmfut_abertura'}, inplace=True)
ccmfut_df.rename(columns= {'Máxima': 'ccmfut_máxima'}, inplace=True)
ccmfut_df.rename(columns= {'Mínima': 'ccmfut_mínima'}, inplace=True)
ccmfut_df.rename(columns= {'Fechamento': 'ccmfut_fechamento'}, inplace=True)
ccmfut_df.rename(columns= {'Volume Financeiro': 'ccmfut_volume_fin'}, inplace=True)
ccmfut_df
```

Out[237…

	Data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
0	2021-03-05	94.10	96.46	94.10	95.85	380377381.5
1	2021-03-04	91.00	94.72	90.40	94.20	325967202.0
2	2021-03-03	89.00	91.10	88.86	91.05	211768164.0
3	2021-03-02	88.80	89.06	88.54	88.94	95795617.5
4	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
...	...	...	...	...	...	...
2914	2008-10-02	22.64	22.64	22.64	22.64	11295.0
2915	2008-09-30	22.55	22.55	22.55	22.55	112500.0
2916	2008-09-26	22.68	22.68	22.68	22.68	565875.0
2917	2008-09-22	22.64	22.64	22.64	22.64	112950.0
2918	2008-09-19	22.64	22.64	22.64	22.64	1129500.0

2919 rows × 6 columns

In [238…

```
ccmfut_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2919 entries, 0 to 2918
Data columns (total 6 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   Data                2919 non-null   datetime64[ns]
 1   ccmfut_abertura     2919 non-null   float64
 2   ccmfut_máxima       2919 non-null   float64
 3   ccmfut_mínima       2919 non-null   float64
 4   ccmfut_fechamento   2919 non-null   float64
 5   ccmfut_volume_fin   2919 non-null   float64
dtypes: datetime64[ns](1), float64(5)
memory usage: 137.0 KB
```

In [239…

```
ccmfut_df = ccmfut_df.drop(ccmfut_df.index[0:2])
ccmfut_df
```

Out[239…

	Data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
2	2021-03-03	89.00	91.10	88.86	91.05	211768164.0
3	2021-03-02	88.80	89.06	88.54	88.94	95795617.5
4	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
5	2021-02-26	89.61	89.64	88.86	88.86	69200707.5
6	2021-02-25	89.45	89.72	88.81	89.63	106361550.0
...	...	...	...	...	...	...
2914	2008-10-02	22.64	22.64	22.64	22.64	11295.0
2915	2008-09-30	22.55	22.55	22.55	22.55	112500.0
2916	2008-09-26	22.68	22.68	22.68	22.68	565875.0
2917	2008-09-22	22.64	22.64	22.64	22.64	112950.0
2918	2008-09-19	22.64	22.64	22.64	22.64	1129500.0

2917 rows × 6 columns

In [240…

```
ccmfut_df = ccmfut_df.sort_values(by = ['Data'])
ccmfut_df
```

Out[240…

	Data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
2918	2008-09-19	22.64	22.64	22.64	22.64	1129500.0
2917	2008-09-22	22.64	22.64	22.64	22.64	112950.0

	Data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
2916	2008-09-26	22.68	22.68	22.68	22.68	565875.0
2915	2008-09-30	22.55	22.55	22.55	22.55	112500.0
2914	2008-10-02	22.64	22.64	22.64	22.64	11295.0
...	...	...	...	...	...	...
6	2021-02-25	89.45	89.72	88.81	89.63	106361550.0
5	2021-02-26	89.61	89.64	88.86	88.86	69200707.5
4	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
3	2021-03-02	88.80	89.06	88.54	88.94	95795617.5
2	2021-03-03	89.00	91.10	88.86	91.05	211768164.0

2917 rows × 6 columns

In [241…
```
ccmfut_df.index
```

Out[241…
```
Int64Index([2918, 2917, 2916, 2915, 2914, 2913, 2912, 2911, 2910, 2909,
            ...
              11,   10,    9,    8,    7,    6,    5,    4,    3,    2],
           dtype='int64', length=2917)
```

In [242…
```
ccmfut_df.index = pd.to_datetime(ccmfut_df.Data)
ccmfut_df.index.to_period('D')
ccmfut_df.index
```

Out[242…
```
DatetimeIndex(['2008-09-19', '2008-09-22', '2008-09-26', '2008-09-30',
               '2008-10-02', '2008-10-03', '2008-10-06', '2008-10-07',
               '2008-10-08', '2008-10-09',
               ...
               '2021-02-18', '2021-02-19', '2021-02-22', '2021-02-23',
               '2021-02-24', '2021-02-25', '2021-02-26', '2021-03-01',
               '2021-03-02', '2021-03-03'],
              dtype='datetime64[ns]', name='Data', length=2917, freq=None)
```

In [243…
```
ccmfut_df.isnull().sum()
```

Out[243…
```
Data                 0
ccmfut_abertura      0
ccmfut_máxima        0
ccmfut_mínima        0
ccmfut_fechamento    0
ccmfut_volume_fin    0
dtype: int64
```

In [244…
```
milho_df.rename(columns= {'Data': 'data'}, inplace=True)
ccmfut_df.rename(columns= {'Data': 'data'}, inplace=True)
```

In [245…

```
milho_df
```

Out[245…

	data	milho_reais	milho_dolares
Data			
2004-08-02	2004-08-02	18.24	5.98
2004-08-03	2004-08-03	18.04	5.91
2004-08-04	2004-08-04	18.02	5.90
2004-08-05	2004-08-05	18.06	5.89
2004-08-06	2004-08-06	18.13	5.98
...	...	...	...
2021-02-25	2021-02-25	85.59	15.55
2021-02-26	2021-02-26	85.41	15.30
2021-03-01	2021-03-01	85.59	15.29
2021-03-02	2021-03-02	86.11	15.20
2021-03-03	2021-03-03	87.06	15.14

4127 rows × 3 columns

In [246…

```
ccmfut_df
```

Out[246…

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
Data						
2008-09-19	2008-09-19	22.64	22.64	22.64	22.64	1129500.0
2008-09-22	2008-09-22	22.64	22.64	22.64	22.64	112950.0
2008-09-26	2008-09-26	22.68	22.68	22.68	22.68	565875.0
2008-09-30	2008-09-30	22.55	22.55	22.55	22.55	112500.0
2008-10-02	2008-10-02	22.64	22.64	22.64	22.64	11295.0
...	...	...	...	...	...	...
2021-02-25	2021-02-25	89.45	89.72	88.81	89.63	106361550.0
2021-02-26	2021-02-26	89.61	89.64	88.86	88.86	69200707.5
2021-03-01	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
2021-03-02	2021-03-02	88.80	89.06	88.54	88.94	95795617.5

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
Data						
2021-03-03	2021-03-03	89.00	91.10	88.86	91.05	211768164.0

2917 rows × 6 columns

In [247…

```
mc_df = ccmfut_df.merge(
    milho_df.set_index('data'), how='left', on='data'
)
```

In [248…

```
mc_df
```

Out[248…

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
0	2008-09-19	22.64	22.64	22.64	22.64	1129500.0
1	2008-09-22	22.64	22.64	22.64	22.64	112950.0
2	2008-09-26	22.68	22.68	22.68	22.68	565875.0
3	2008-09-30	22.55	22.55	22.55	22.55	112500.0
4	2008-10-02	22.64	22.64	22.64	22.64	11295.0
...	...	...	...	...	...	...
2912	2021-02-25	89.45	89.72	88.81	89.63	106361550.0
2913	2021-02-26	89.61	89.64	88.86	88.86	69200707.5
2914	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
2915	2021-03-02	88.80	89.06	88.54	88.94	95795617.5
2916	2021-03-03	89.00	91.10	88.86	91.05	211768164.0

2917 rows × 8 columns

In [249…

```
mc_df.isnull().sum()
```

Out[249…

```
data                 0
ccmfut_abertura      0
ccmfut_máxima        0
ccmfut_mínima        0
ccmfut_fechamento    0
```

```
ccmfut_volume_fin    0
milho_reais          2
milho_dolares        2
dtype: int64
```

In [250...

```
mc_df_mvmilho_reais = mc_df["milho_reais"].rolling(5).mean().shift(-5).round(0)
mc_df_mvmilho_dolares = mc_df["milho_dolares"].rolling(5).mean().shift(-5).round(0)
mc_df["milho_reais"].fillna(mc_df_mvmilho_reais, inplace=True)
mc_df["milho_dolares"].fillna(mc_df_mvmilho_dolares, inplace=True)
```

In [251...

```
mc_df.isnull().sum()
```

Out[251...

```
data                 0
ccmfut_abertura      0
ccmfut_máxima        0
ccmfut_mínima        0
ccmfut_fechamento    0
ccmfut_volume_fin    0
milho_reais          1
milho_dolares        1
dtype: int64
```

In [252...

```
mc_df_mvmilho_reais = mc_df["milho_reais"].rolling(5).mean().shift(-5).round(0)
mc_df_mvmilho_dolares = mc_df["milho_dolares"].rolling(5).mean().shift(-5).round(0)
mc_df["milho_reais"].fillna(mc_df_mvmilho_reais, inplace=True)
mc_df["milho_dolares"].fillna(mc_df_mvmilho_dolares, inplace=True)
```

In [253...

```
mc_df.isnull().sum()
```

Out[253...

```
data                 0
ccmfut_abertura      0
ccmfut_máxima        0
ccmfut_mínima        0
ccmfut_fechamento    0
ccmfut_volume_fin    0
milho_reais          0
milho_dolares        0
dtype: int64
```

In [254...

```
mc_df = mc_df.sort_values(by = ['data'])
mc_df
```

Out[254...

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
0	2008-09-19	22.64	22.64	22.64	22.64	1129500.0
1	2008-09-22	22.64	22.64	22.64	22.64	112950.0
2	2008-09-26	22.68	22.68	22.68	22.68	565875.0
3	2008-09-30	22.55	22.55	22.55	22.55	112500.0
4	2008-10-02	22.64	22.64	22.64	22.64	11295.0
...	...	...	...	...	...	...

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
2912	2021-02-25	89.45	89.72	88.81	89.63	106361550.0
2913	2021-02-26	89.61	89.64	88.86	88.86	69200707.5
2914	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
2915	2021-03-02	88.80	89.06	88.54	88.94	95795617.5
2916	2021-03-03	89.00	91.10	88.86	91.05	211768164.0

2917 rows × 8 columns

In [255…

```
mc_df.index = pd.to_datetime(mc_df.data)
mc_df.index.to_period('D')
mc_df.index
```

Out[255…

```
DatetimeIndex(['2008-09-19', '2008-09-22', '2008-09-26', '2008-09-30',
               '2008-10-02', '2008-10-03', '2008-10-06', '2008-10-07',
               '2008-10-08', '2008-10-09',
               ...
               '2021-02-18', '2021-02-19', '2021-02-22', '2021-02-23',
               '2021-02-24', '2021-02-25', '2021-02-26', '2021-03-01',
               '2021-03-02', '2021-03-03'],
              dtype='datetime64[ns]', name='data', length=2917, freq=None)
```

In [256…

```
mc_df
```

Out[256…

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
data						
2008-09-19	2008-09-19	22.64	22.64	22.64	22.64	1129500.0
2008-09-22	2008-09-22	22.64	22.64	22.64	22.64	112950.0
2008-09-26	2008-09-26	22.68	22.68	22.68	22.68	565875.0
2008-09-30	2008-09-30	22.55	22.55	22.55	22.55	112500.0
2008-10-02	2008-10-02	22.64	22.64	22.64	22.64	11295.0
...	...	...	...	...	...	...
2021-02-25	2021-02-25	89.45	89.72	88.81	89.63	106361550.0
2021-02-26	2021-02-26	89.61	89.64	88.86	88.86	69200707.5

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
data						
2021-03-01	2021-03-01	88.92	89.18	88.00	88.70	133054398.0
2021-03-02	2021-03-02	88.80	89.06	88.54	88.94	95795617.5
2021-03-03	2021-03-03	89.00	91.10	88.86	91.05	211768164.0

2917 rows × 8 columns

In [257…

```
# 3 - Analise e Exploracao dos Dados
```

In [258…

```
milho_df.describe()
```

Out[258…

	milho_reais	milho_dolares
count	4127.000000	4127.000000
mean	30.409537	11.535544
std	12.350048	3.276651
min	13.320000	5.890000
25%	21.325000	9.250000
50%	27.770000	10.720000
75%	35.375000	13.750000
max	87.060000	19.960000

In [259…

```
milho_df[milho_df['milho_reais']==milho_df['milho_reais'].max()]
```

Out[259…

	data	milho_reais	milho_dolares
Data			
2021-03-03	2021-03-03	87.06	15.14

In [260…

```
milho_df[milho_df['milho_dolares']==milho_df['milho_dolares'].max()]
```

Out[260…

	data	milho_reais	milho_dolares
Data			
2011-07-01	2011-07-01	31.08	19.96

In [261…

```
milho_df[milho_df['milho_reais']==milho_df['milho_reais'].min()]
```

Out[261…

	data	milho_reais	milho_dolares

Data	data	milho_reais	milho_dolares
Data			
2006-03-30	2006-03-30	13.32	6.08

In [262…

```
milho_df[milho_df['milho_dolares']==milho_df['milho_dolares'].min()]
```

Out[262…

	data	milho_reais	milho_dolares
Data			
2004-08-05	2004-08-05	18.06	5.89

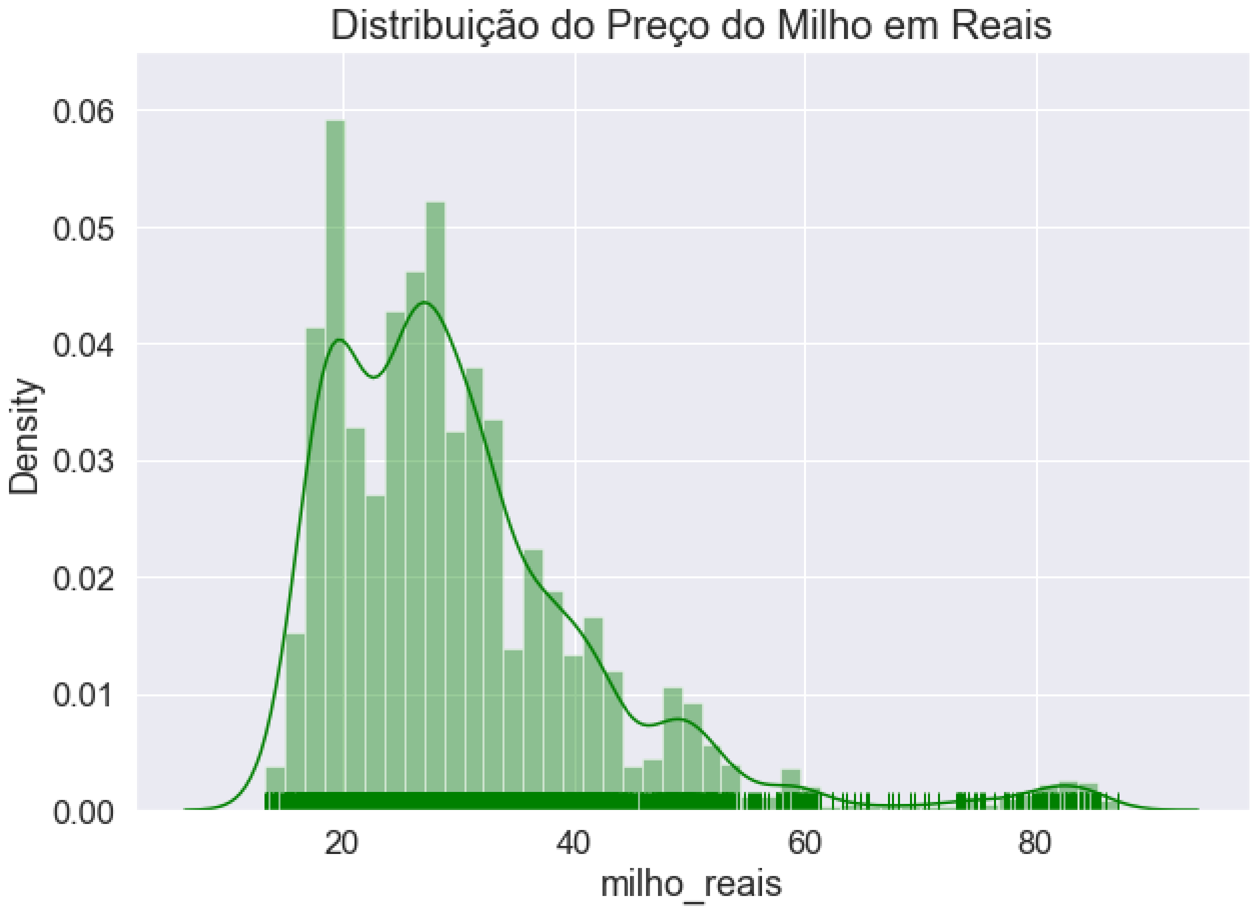
In [263…

```
plt.figure(figsize=(10,7))
sns.set_context('notebook', font_scale=1.5, rc={'font.size':20, 'axes.titlesize':20, 'a
sns.distplot(milho_df['milho_reais'], rug=True, color= 'green')
sns.set_style('darkgrid')
plt.title('Distribuição do Preço do Milho em Reais')
```

```
C:\Users\Jonathan Lincher\anaconda3\lib\site-packages\seaborn\distributions.py:2551: Fut
ureWarning:

`distplot` is a deprecated function and will be removed in a future version. Please adap
t your code to use either `displot` (a figure-level function with similar flexibility) o
r `histplot` (an axes-level function for histograms).

C:\Users\Jonathan Lincher\anaconda3\lib\site-packages\seaborn\distributions.py:2055: Fut
ureWarning:

The `axis` variable is no longer used and will be removed. Instead, assign variables dir
ectly to `x` or `y`.
```

Out[263…

```
Text(0.5, 1.0, 'Distribuição do Preço do Milho em Reais')
```



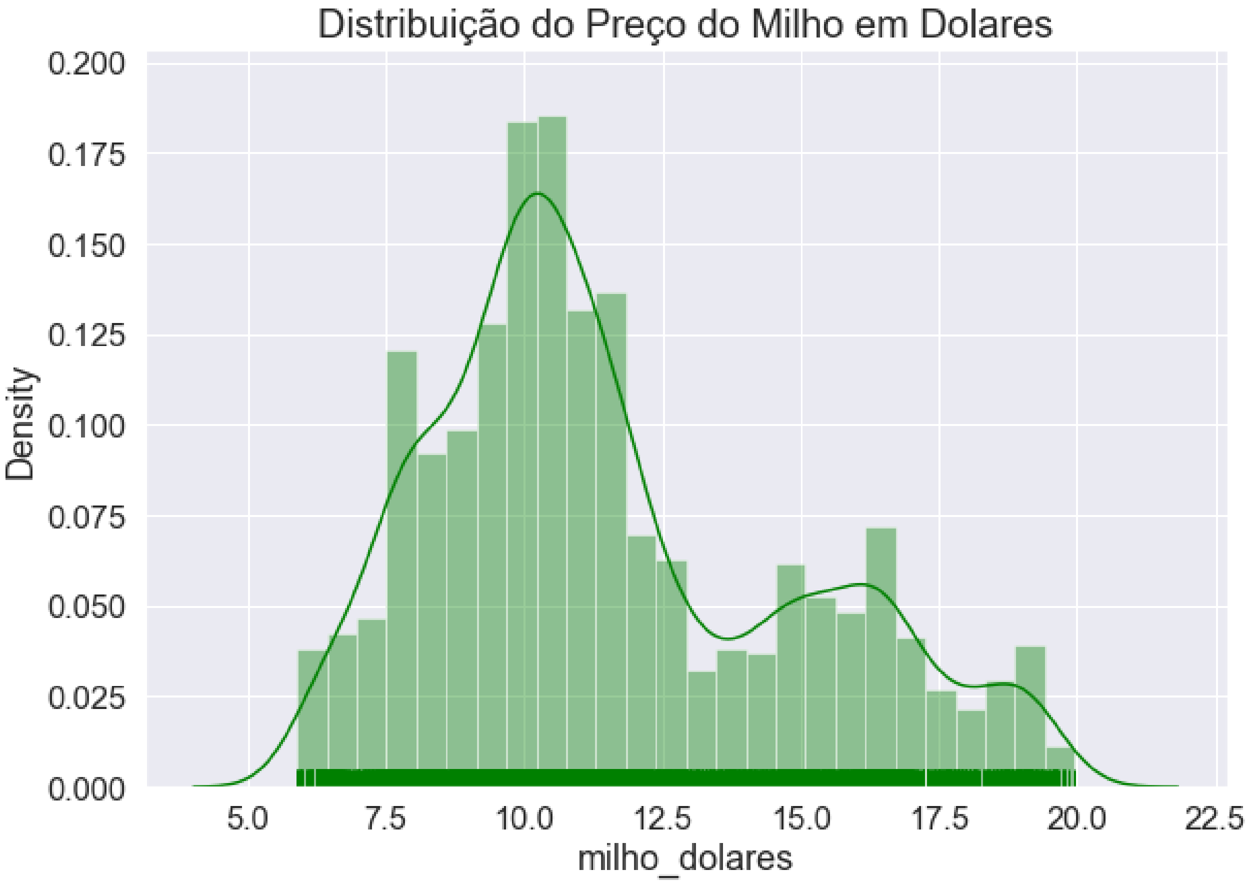
In [264…

```
plt.figure(figsize=(10,7))
sns.set_context('notebook', font_scale=1.5, rc={'font.size':20, 'axes.titlesize':20, 'a
sns.distplot(milho_df['milho_dolares'], rug=True, color= 'green')
sns.set_style('darkgrid')
plt.title('Distribuição do Preço do Milho em Dolares')
```

```
C:\Users\Jonathan Lincher\anaconda3\lib\site-packages\seaborn\distributions.py:2551: Fut
ureWarning:

`distplot` is a deprecated function and will be removed in a future version. Please adap
t your code to use either `displot` (a figure-level function with similar flexibility) o
r `histplot` (an axes-level function for histograms).

C:\Users\Jonathan Lincher\anaconda3\lib\site-packages\seaborn\distributions.py:2055: Fut
ureWarning:

The `axis` variable is no longer used and will be removed. Instead, assign variables dir
ectly to `x` or `y`.
```

Out[264…

```
Text(0.5, 1.0, 'Distribuição do Preço do Milho em Dolares')
```



In [265…

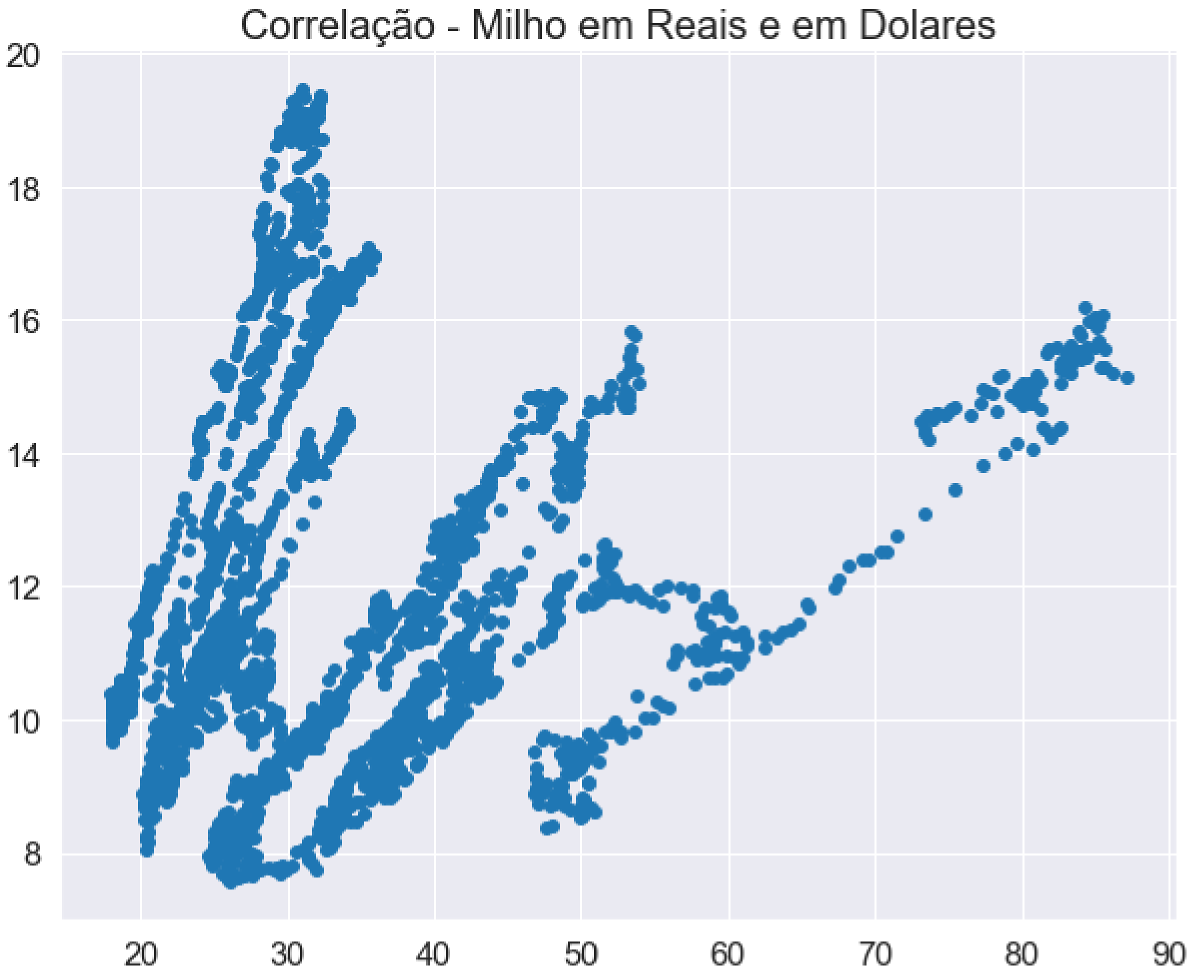
```
mc_df['milho_reais'].corr(mc_df['milho_dolares'])
```

Out[265…

```
0.1816166279649749
```

In [266…

```
data1=mc_df['milho_reais']
data2=mc_df['milho_dolares']
plt.scatter(data1, data2)
plt.title('Correlação - Milho em Reais e em Dolares')
plt.gcf().set_size_inches(10, 8)
plt.show()
```



In [267…

```
def interactive_plot(df, title):
  fig = px.line(title = title)
  for i in df.columns[1:]:
    fig.add_scatter(x = df['data'], y = df[i], name = i)
  fig.show()
```

In [268…

```
interactive_plot(milho_df, "Milho em Reais e Milho em Dolares")
```

In [269…

```python
dolar_df = pd.read_csv('USD_BRL Dados Históricos.csv', decimal=",")
dolar_df
```

Out[269…

	Data	Último	Abertura	Máxima	Mínima	Var%
0	03.03.2021	5.6193	5.6872	5.7729	5.5806	-1,01%
1	02.03.2021	5.6764	5.6386	5.7327	5.6386	0,61%
2	01.03.2021	5.6418	5.5870	5.6427	5.5553	0,77%
3	26.02.2021	5.5986	5.5340	5.6093	5.4905	1,23%
4	25.02.2021	5.5308	5.4450	5.5390	5.4173	2,30%
...	...	...	...	...	...	...
4319	06.08.2004	3.0330	3.0722	3.0780	3.0300	-1,25%
4320	05.08.2004	3.0713	3.0540	3.0713	3.0500	0,58%
4321	04.08.2004	3.0537	3.0500	3.0660	3.0460	0,12%
4322	03.08.2004	3.0500	3.0450	3.0620	3.0440	0,11%
4323	02.08.2004	3.0465	3.0365	3.0585	3.0365	0,30%

4324 rows × 6 columns

In [270…

```python
dolar_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4324 entries, 0 to 4323
Data columns (total 6 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   Data      4324 non-null   object 
 1   Último    4324 non-null   float64
 2   Abertura  4324 non-null   float64
 3   Máxima    4324 non-null   float64
 4   Mínima    4324 non-null   float64
 5   Var%      4324 non-null   object 
dtypes: float64(4), object(2)
memory usage: 202.8+ KB
```

In [271…

```python
dolar_df = dolar_df.drop(columns=dolar_df.columns[2:])
dolar_df
```

Out[271…

	Data	Último

	Data	Último
0	03.03.2021	5.6193
1	02.03.2021	5.6764
2	01.03.2021	5.6418
3	26.02.2021	5.5986
4	25.02.2021	5.5308
...	...	...
4319	06.08.2004	3.0330
4320	05.08.2004	3.0713
4321	04.08.2004	3.0537
4322	03.08.2004	3.0500
4323	02.08.2004	3.0465

4324 rows × 2 columns

In [272...

```
dolar_df ['Data'] = pd.to_datetime(dolar_df ['Data'],dayfirst=True)
dolar_df = dolar_df.sort_values(by = ['Data'])
dolar_df['Data']
```

Out[272...

```
4323   2004-08-02
4322   2004-08-03
4321   2004-08-04
4320   2004-08-05
4319   2004-08-06
          ...
4      2021-02-25
3      2021-02-26
2      2021-03-01
1      2021-03-02
0      2021-03-03
Name: Data, Length: 4324, dtype: datetime64[ns]
```

In [273...

```
dolar_df.index = pd.to_datetime(dolar_df.Data)
dolar_df.index.to_period('D')
dolar_df.index
```

Out[273...

```
DatetimeIndex(['2004-08-02', '2004-08-03', '2004-08-04', '2004-08-05',
               '2004-08-06', '2004-08-09', '2004-08-10', '2004-08-11',
               '2004-08-12', '2004-08-13',
               ...
               '2021-02-18', '2021-02-19', '2021-02-22', '2021-02-23',
               '2021-02-24', '2021-02-25', '2021-02-26', '2021-03-01',
               '2021-03-02', '2021-03-03'],
              dtype='datetime64[ns]', name='Data', length=4324, freq=None)
```

In [274...

```
dolar_df.rename(columns= {'Data': 'data'}, inplace=True)
dolar_df.rename(columns= {'Último': 'Dolar_Último'}, inplace=True)
```

In [275...

```
dolar_df
```

Out[275...

	data	Dolar_Último

Data	data	Dolar_Último
Data		
2004-08-02	2004-08-02	3.0465
2004-08-03	2004-08-03	3.0500
2004-08-04	2004-08-04	3.0537
2004-08-05	2004-08-05	3.0713
2004-08-06	2004-08-06	3.0330
...	...	...
2021-02-25	2021-02-25	5.5308
2021-02-26	2021-02-26	5.5986
2021-03-01	2021-03-01	5.6418
2021-03-02	2021-03-02	5.6764
2021-03-03	2021-03-03	5.6193

4324 rows × 2 columns

In [276…

```
milho_df
```

Out[276…

	data	milho_reais	milho_dolares
Data			
2004-08-02	2004-08-02	18.24	5.98
2004-08-03	2004-08-03	18.04	5.91
2004-08-04	2004-08-04	18.02	5.90
2004-08-05	2004-08-05	18.06	5.89
2004-08-06	2004-08-06	18.13	5.98
...	...	...	...
2021-02-25	2021-02-25	85.59	15.55
2021-02-26	2021-02-26	85.41	15.30
2021-03-01	2021-03-01	85.59	15.29
2021-03-02	2021-03-02	86.11	15.20
2021-03-03	2021-03-03	87.06	15.14

4127 rows × 3 columns

In [277…

```
dolar_milho_df = pd.merge(milho_df,dolar_df, how='inner', on=['Data'],suffixes=('_M', '
dolar_milho_df
```

Out[277…

	data_M	milho_reais	milho_dolares	data_D	Dolar_Último

	data_M	milho_reais	milho_dolares	data_D	Dolar_Último
Data					
2004-08-02	2004-08-02	18.24	5.98	2004-08-02	3.0465
2004-08-03	2004-08-03	18.04	5.91	2004-08-03	3.0500
2004-08-04	2004-08-04	18.02	5.90	2004-08-04	3.0537
2004-08-05	2004-08-05	18.06	5.89	2004-08-05	3.0713
2004-08-06	2004-08-06	18.13	5.98	2004-08-06	3.0330
...	...	...	...	...	...
2021-02-25	2021-02-25	85.59	15.55	2021-02-25	5.5308
2021-02-26	2021-02-26	85.41	15.30	2021-02-26	5.5986
2021-03-01	2021-03-01	85.59	15.29	2021-03-01	5.6418
2021-03-02	2021-03-02	86.11	15.20	2021-03-02	5.6764
2021-03-03	2021-03-03	87.06	15.14	2021-03-03	5.6193

4127 rows × 5 columns

In [278…

```
dolar_milho_df = dolar_milho_df.drop(columns='data_D')
dolar_milho_df
```

Out[278…

	data_M	milho_reais	milho_dolares	Dolar_Último
Data				
2004-08-02	2004-08-02	18.24	5.98	3.0465
2004-08-03	2004-08-03	18.04	5.91	3.0500
2004-08-04	2004-08-04	18.02	5.90	3.0537
2004-08-05	2004-08-05	18.06	5.89	3.0713
2004-08-06	2004-08-06	18.13	5.98	3.0330
...	...	...	...	...
2021-02-25	2021-02-25	85.59	15.55	5.5308
2021-02-26	2021-02-26	85.41	15.30	5.5986
2021-03-01	2021-03-01	85.59	15.29	5.6418
2021-03-02	2021-03-02	86.11	15.20	5.6764
2021-03-03	2021-03-03	87.06	15.14	5.6193

4127 rows × 4 columns

In [279…

```
dolar_milho_df['milho_reais'].corr(dolar_milho_df['Dolar_Último'])
```

Out[279…

```
0.7824021362013128
```

In [280…

```
ccmfut_df.describe()
```

Out[280…

	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_fechamento	ccmfut_volume_fin
count	2917.000000	2917.000000	2917.000000	2917.000000	2.917000e+03
mean	26.723809	26.988920	26.474443	26.742749	3.300606e+07
std	13.506372	13.711821	13.312827	13.540517	4.274579e+07
min	12.680000	12.800000	12.310000	12.710000	0.000000e+00
25%	19.620000	19.780000	19.500000	19.640000	1.002070e+07
50%	22.560000	22.760000	22.350000	22.560000	2.244742e+07
75%	30.140000	30.510000	29.820000	30.140000	3.881796e+07
max	89.730000	91.120000	89.280000	91.050000	6.528013e+08

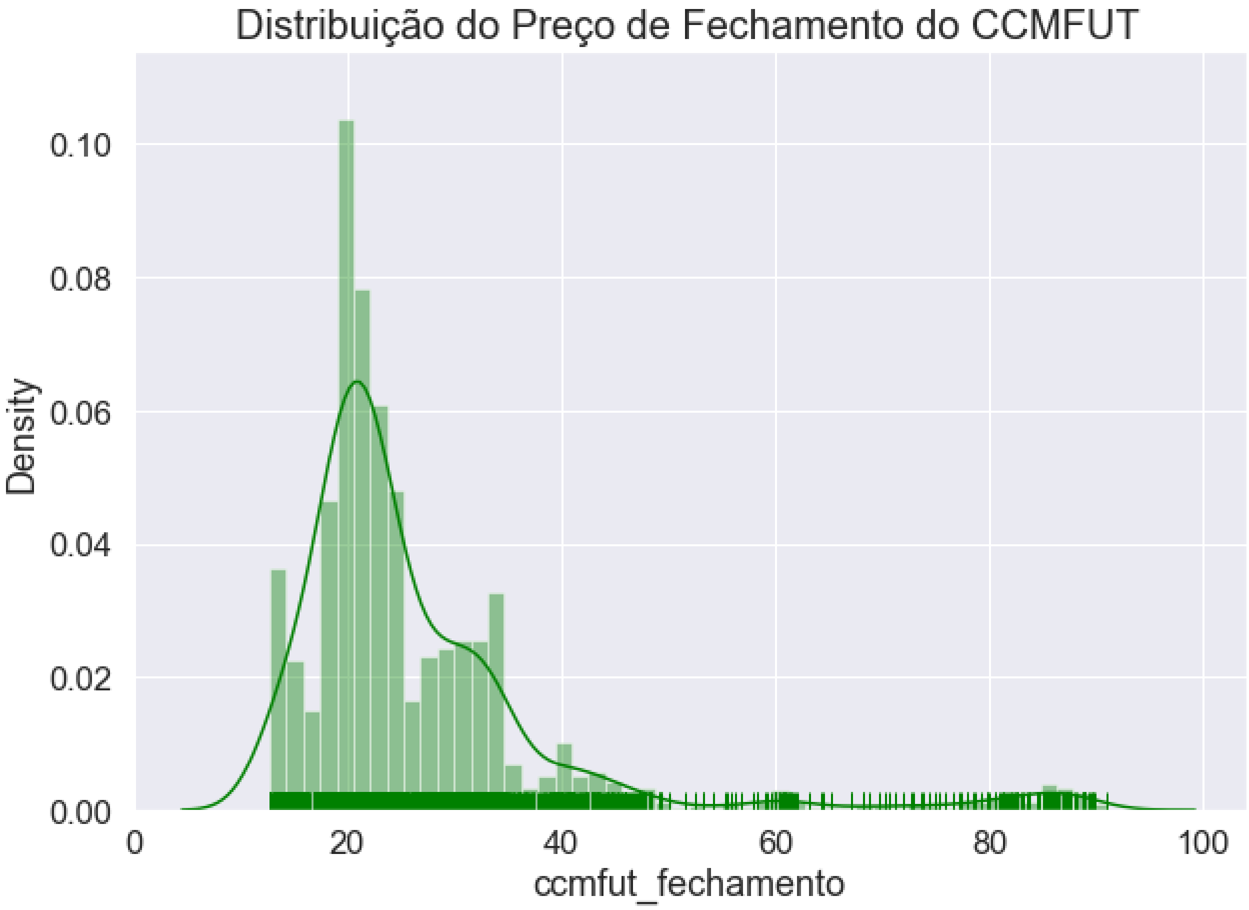
In [281…

```
plt.figure(figsize=(10,7))
sns.set_context('notebook', font_scale=1.5, rc={'font.size':20, 'axes.titlesize':20, 'a
sns.distplot(ccmfut_df['ccmfut_fechamento'], rug=True, color= 'green')
sns.set_style('darkgrid')
plt.title('Distribuição do Preço de Fechamento do CCMFUT')
```

```
C:\Users\Jonathan Lincher\anaconda3\lib\site-packages\seaborn\distributions.py:2551: Fut
ureWarning:

`distplot` is a deprecated function and will be removed in a future version. Please adap
t your code to use either `displot` (a figure-level function with similar flexibility) o
r `histplot` (an axes-level function for histograms).

C:\Users\Jonathan Lincher\anaconda3\lib\site-packages\seaborn\distributions.py:2055: Fut
ureWarning:

The `axis` variable is no longer used and will be removed. Instead, assign variables dir
ectly to `x` or `y`.
```

Out[281…

```
Text(0.5, 1.0, 'Distribuição do Preço de Fechamento do CCMFUT')
```



In [282…

```
def interactive_plot(df, title):
  fig = px.line(title = title)
  for i in df.columns[1:]:
    fig.add_scatter(x = df['data'], y = df[i], name = i)
  fig.show()
```

In [283…

```
interactive_plot(ccmfut_df, "Historico de Precos - CCMFUT")
```

In [284…

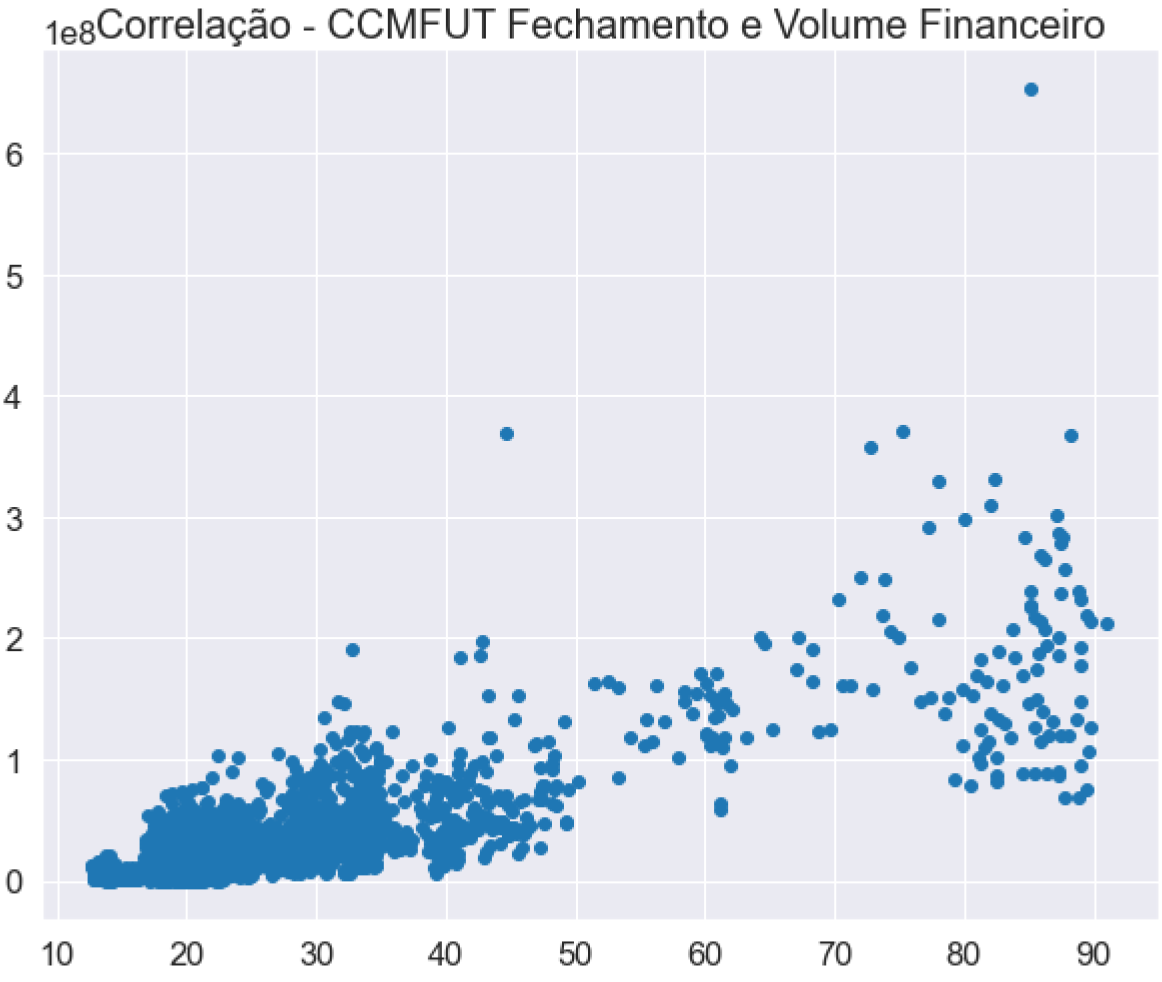
```
ccmfut_df['ccmfut_fechamento'].corr(ccmfut_df['ccmfut_volume_fin'])
```

Out[284…

```
0.7999203525936038
```

In [285…

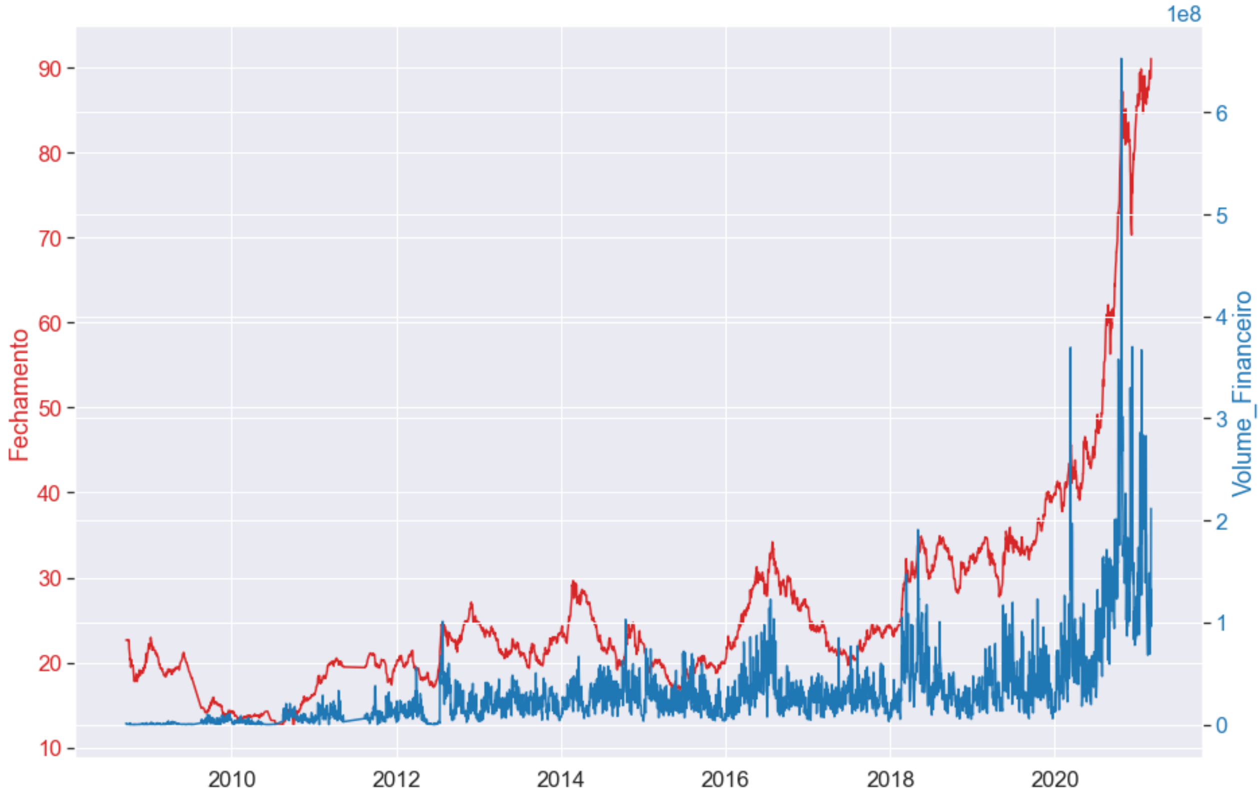
```
data1=ccmfut_df['ccmfut_fechamento']
data2=ccmfut_df['ccmfut_volume_fin']
plt.scatter(data1, data2)
plt.title('Correlação - CCMFUT Fechamento e Volume Financeiro')
plt.gcf().set_size_inches(10, 8)
plt.show()
```



In [286…

```
b = ccmfut_df["data"]
data1 = ccmfut_df["ccmfut_fechamento"]
data2 = ccmfut_df["ccmfut_volume_fin"]

fig, ax1 = plt.subplots()
```

```
color = 'tab:red'
ax1.set_xlabel('')
ax1.set_ylabel('Fechamento', color=color)
ax1.plot(b, data1, color=color)
ax1.tick_params(axis='y', labelcolor=color)

ax2 = ax1.twinx()

color = 'tab:blue'
ax2.set_ylabel('Volume_Financeiro', color=color)
ax2.plot(b, data2, color=color)
ax2.tick_params(axis='y', labelcolor=color)
plt.gcf().set_size_inches(15, 10)
plt.show()
```



In [287…

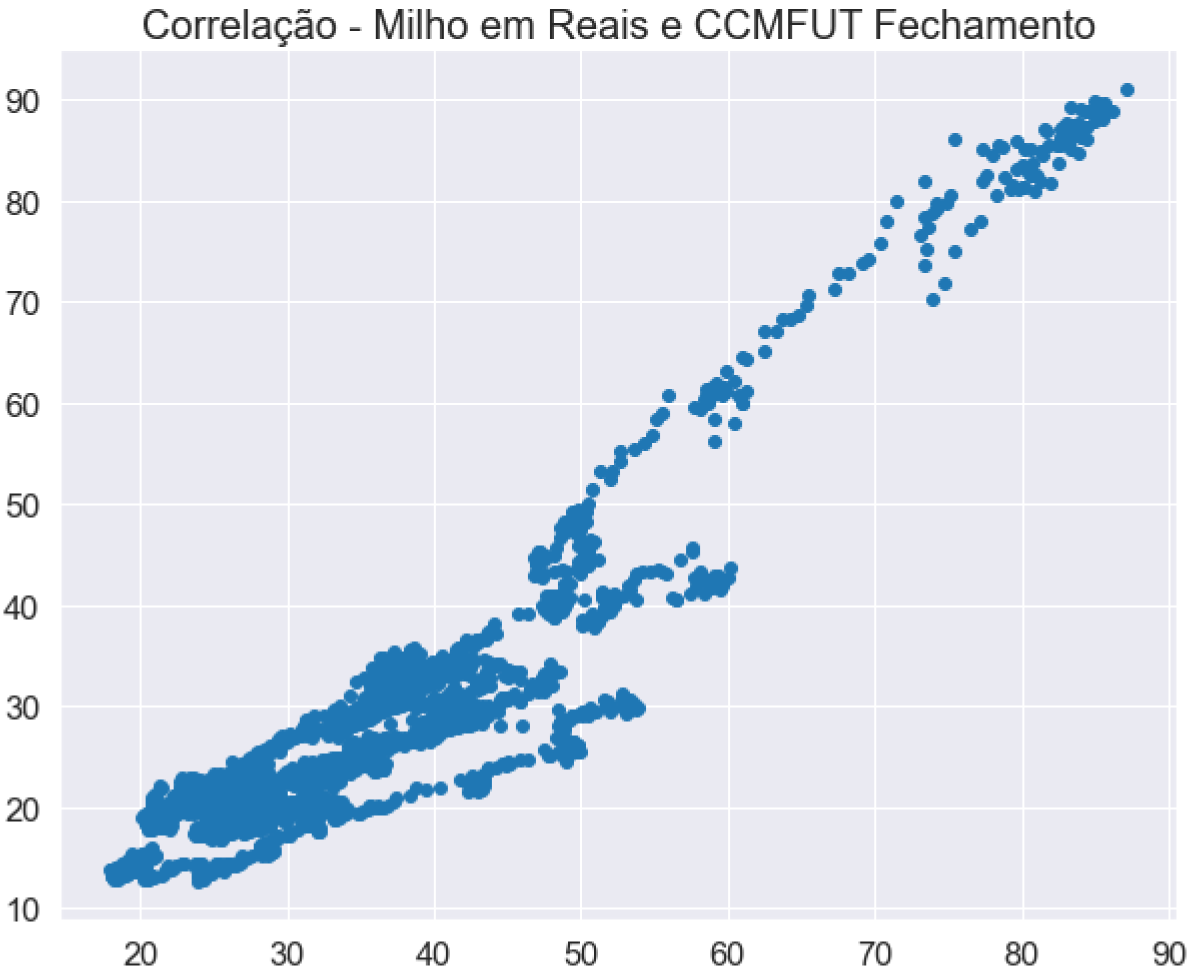
```
mc_df['milho_reais'].corr(mc_df['ccmfut_fechamento'])
```

Out[287…

```
0.928074900682255
```

In [288…

```
data1=mc_df['milho_reais']
data2=mc_df['ccmfut_fechamento']
plt.scatter(data1, data2)
plt.title('Correlação - Milho em Reais e CCMFUT Fechamento')
plt.gcf().set_size_inches(10, 8)
plt.show()
```



In [289…

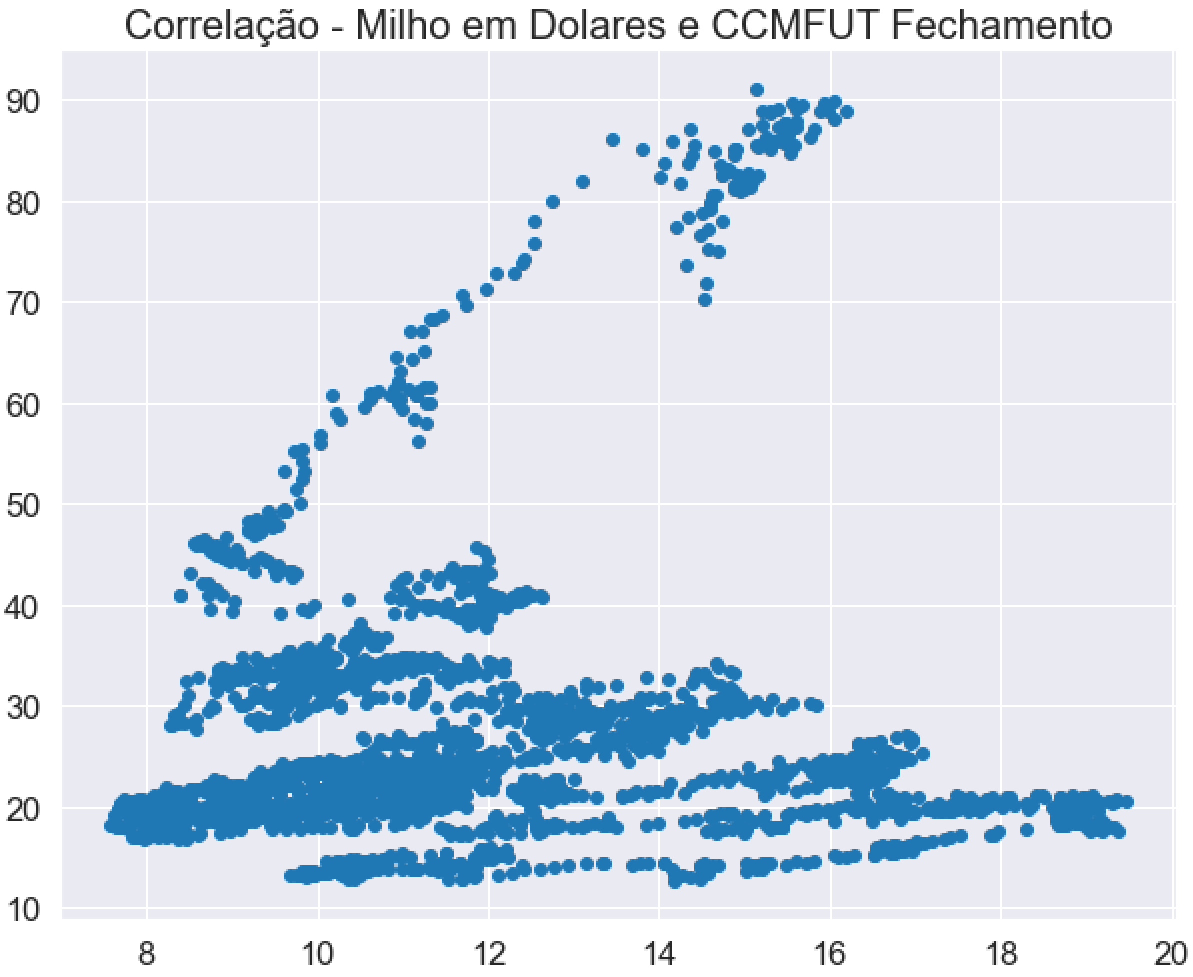
```
mc_df['milho_dolares'].corr(mc_df['ccmfut_fechamento'])
```

Out[289…

```
0.065512943089332
```

In [290…

```
data1=mc_df['milho_dolares']
data2=mc_df['ccmfut_fechamento']
plt.scatter(data1, data2)
plt.title('Correlação - Milho em Dolares e CCMFUT Fechamento')
plt.gcf().set_size_inches(10, 8)
plt.show()
```



Correlação - Milho em Dolares e CCMFUT Fechamento

In [291…

```
mc_df = mc_df[['data', 'ccmfut_abertura', 'ccmfut_máxima', 'ccmfut_mínima' , 'ccmfut_vo
```

In [292…

```
def interactive_plot(df, title):
  fig = px.line(title = title)
  for i in df.columns[5:]:
    fig.add_scatter(x = df['data'], y = df[i], name = i)
  fig.show()
```

In [293…

```
interactive_plot(mc_df, "CCMFUT Fechamento, Milho em Reais e Milho em Dolares")
```

In [294...

```
# 4 - Ridge Regression
```

In [295...

```
mc_df['ccmfut_fechamento_alvo'] = mc_df[['ccmfut_fechamento']].shift(-1)
mc_df = mc_df[:-1]
mc_df
```

Out[295...

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_volume_fin	ccmfut_fechamento
data						
2008-09-19	2008-09-19	22.64	22.64	22.64	1129500.0	22.64
2008-09-22	2008-09-22	22.64	22.64	22.64	112950.0	22.64
2008-09-26	2008-09-26	22.68	22.68	22.68	565875.0	22.68
2008-09-30	2008-09-30	22.55	22.55	22.55	112500.0	22.55
2008-10-02	2008-10-02	22.64	22.64	22.64	11295.0	22.64
...	...	...	...	...	...	...
2021-02-24	2021-02-24	89.08	89.47	88.42	75830647.5	89.47
2021-02-25	2021-02-25	89.45	89.72	88.81	106361550.0	89.63
2021-02-26	2021-02-26	89.61	89.64	88.86	69200707.5	88.86
2021-03-01	2021-03-01	88.92	89.18	88.00	133054398.0	88.70
2021-03-02	2021-03-02	88.80	89.06	88.54	95795617.5	88.94

2916 rows × 9 columns

In [296...

```
from sklearn.preprocessing import MinMaxScaler
```

```
sc = MinMaxScaler(feature_range = (0, 1))
mc_df_scaled = sc.fit_transform(mc_df.drop(columns = ['data']))
```

In [297…

```
mc_df_scaled
```

Out[297…

```
array([[0.12926671, 0.12563841, 0.13420813, ..., 0.08071617, 0.44107744,
        0.12675517],
       [0.12926671, 0.12563841, 0.13420813, ..., 0.07836807, 0.45622896,
        0.12726576],
       [0.12978585, 0.12614913, 0.13472782, ..., 0.07734077, 0.41750842,
        0.12560633],
       ...,
       [0.99844257, 0.98110317, 0.99454333, ..., 0.98972703, 0.64983165,
        0.97000255],
       [0.98948735, 0.97522983, 0.98337014, ..., 0.99236865, 0.6489899 ,
        0.97306612],
       [0.98792992, 0.97369765, 0.99038586, ..., 1.        , 0.64141414,
        1.        ]])
```

In [298…

```
mc_df_scaled.shape
```

Out[298…

```
(2916, 8)
```

In [299…

```
X = mc_df_scaled[:,:7]
y = mc_df_scaled[:,7:]
```

In [300…

```
X
```

Out[300…

```
array([[0.12926671, 0.12563841, 0.13420813, ..., 0.12877707, 0.08071617,
        0.44107744],
       [0.12926671, 0.12563841, 0.13420813, ..., 0.12877707, 0.07836807,
        0.45622896],
       [0.12978585, 0.12614913, 0.13472782, ..., 0.12929581, 0.07734077,
        0.41750842],
       ...,
       [0.99844257, 0.98110317, 0.99454333, ..., 0.98755025, 0.98972703,
        0.64983165],
       [0.98948735, 0.97522983, 0.98337014, ..., 0.9854753 , 0.99236865,
        0.6489899 ],
       [0.98792992, 0.97369765, 0.99038586, ..., 0.98858773, 1.        ,
        0.64141414]])
```

In [301…

```
X.shape
```

Out[301…

```
(2916, 7)
```

In [302…

```
X[0,6]
```

Out[302…

```
0.44107744107744096
```

In [303…

```
y
```

Out[303…

```
array([[0.12675517],
       [0.12726576],
       [0.12560633],
       ...,
       [0.97000255],
       [0.97306612],
       [1.        ]])
```

In [304…

```
X = np.asarray(X)
y = np.asarray(y)
X.shape, y.shape
```

Out[304…

```
((2916, 7), (2916, 1))
```

In [305…

```
X
```

Out[305…

```
array([[0.12926671, 0.12563841, 0.13420813, ..., 0.12877707, 0.08071617,
        0.44107744],
       [0.12926671, 0.12563841, 0.13420813, ..., 0.12877707, 0.07836807,
        0.45622896],
       [0.12978585, 0.12614913, 0.13472782, ..., 0.12929581, 0.07734077,
        0.41750842],
       ...,
       [0.99844257, 0.98110317, 0.99454333, ..., 0.98755025, 0.98972703,
        0.64983165],
       [0.98948735, 0.97522983, 0.98337014, ..., 0.9854753 , 0.99236865,
        0.6489899 ],
       [0.98792992, 0.97369765, 0.99038586, ..., 0.98858773, 1.        ,
        0.64141414]])
```

In [306…

```
y
```

Out[306…

```
array([[0.12675517],
       [0.12726576],
       [0.12560633],
       ...,
       [0.97000255],
       [0.97306612],
       [1.        ]])
```

In [307…

```
split = int(0.70 * len(X))
X_treino = X[:split]
y_treino = y[:split]
X_teste = X[split:]
y_teste = y[split:]
```

In [308…

```
X_treino.shape, y_treino.shape
```

Out[308…

```
((2041, 7), (2041, 1))
```

In [309…

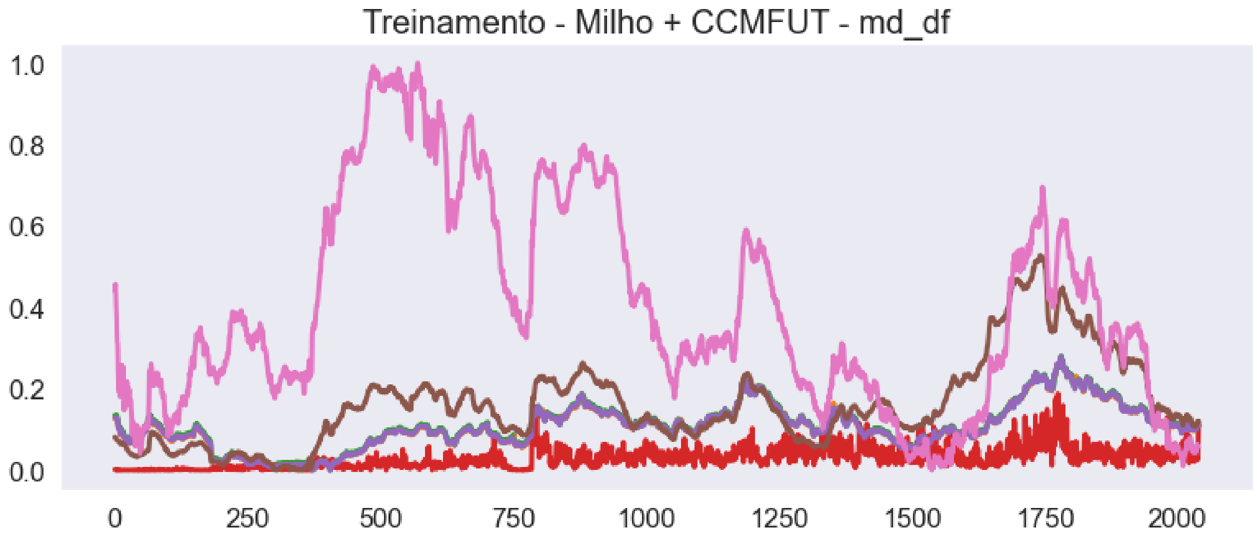
```
X_teste.shape, y_teste.shape
```

Out[309…

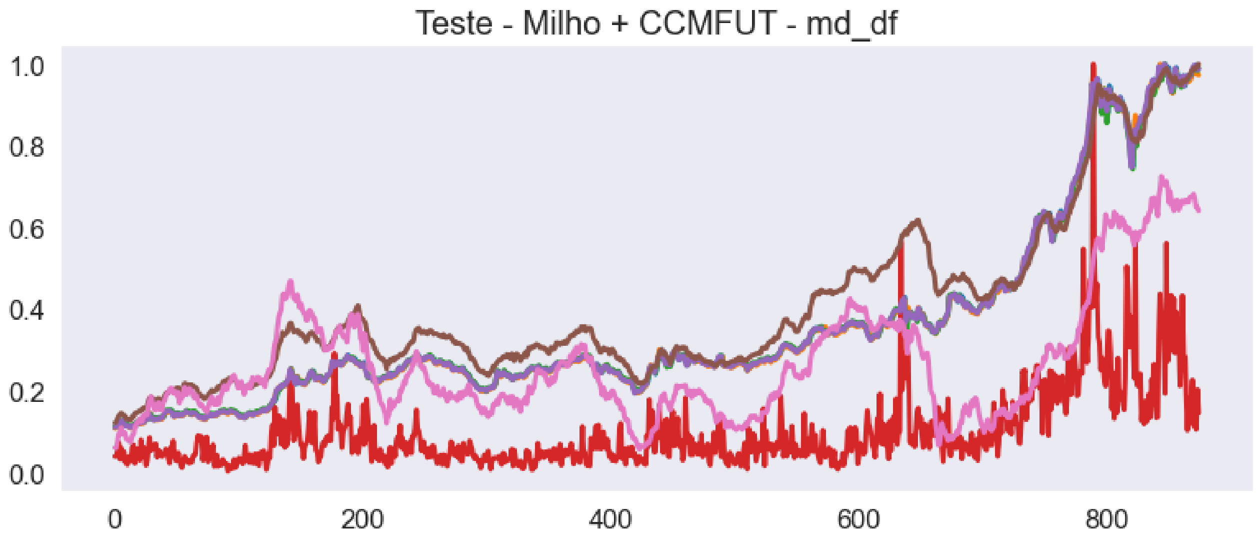
```
((875, 7), (875, 1))
```

In [310…

```
def show_plot_mc(data, title):
  plt.figure(figsize = (13, 5))
  plt.plot(data, linewidth = 3)
  plt.title(title)
  plt.grid()

show_plot_mc(X_treino, 'Treinamento - Milho + CCMFUT - md_df')
show_plot_mc(X_teste, 'Teste - Milho + CCMFUT - md_df')
```



Treinamento - Milho + CCMFUT - md_df



Teste - Milho + CCMFUT - md_df

```
In [311…  from sklearn.linear_model import Ridge
          regression_model = Ridge (alpha=1)
          regression_model.fit(X_treino, y_treino)

Out[311… Ridge(alpha=1)
```

```
In [312…  lr_accuracy = regression_model.score(X_teste, y_teste)
          print("Linear Regression Score: ", lr_accuracy)

          Linear Regression Score:  0.9874692042284041
```

```
In [313…  predicted_prices_mc = regression_model.predict(X)
          predicted_prices_mc

Out[313… array([[0.12060122],
                [0.12045201],
                [0.12093868],
                ...,
                [0.91668274],
                [0.91338118],
                [0.91366199]])
```

```
In [314…  predicted_mc = []
          for i in predicted_prices_mc:
            predicted_mc.append(i[0])
```

In [315…

```
mc_fechamento = []
for i in mc_df_scaled:
  mc_fechamento.append(i[4])
```

In [316…

```
mc_predicao = pd.DataFrame(columns = ['data' , 'mc_fechamento', 'mc_fechamento_predito'
mc_predicao['data'] = mc_df['data']
mc_predicao['mc_fechamento'] = mc_fechamento
mc_predicao['mc_fechamento_predito'] = predicted_mc
mc_predicao
```

Out[316…

	data	mc_fechamento	mc_fechamento_predito
data			
2008-09-19	2008-09-19	0.128777	0.120601
2008-09-22	2008-09-22	0.128777	0.120452
2008-09-26	2008-09-26	0.129296	0.120939
2008-09-30	2008-09-30	0.127610	0.119349
2008-10-02	2008-10-02	0.128777	0.120427
...	...	...	...
2021-02-24	2021-02-24	0.995461	0.915434
2021-02-25	2021-02-25	0.997536	0.920280
2021-02-26	2021-02-26	0.987550	0.916683
2021-03-01	2021-03-01	0.985475	0.913381
2021-03-02	2021-03-02	0.988588	0.913662

2916 rows × 3 columns

In [317…

```
def interactive_plot(data, title):
  fig = px.line(title = title)
  for i in data.columns[1:]:
    fig.add_scatter(x = data['data'], y = data[i], name = i)
  fig.show()
```

In [318…

```
interactive_plot(mc_predicao, "CCMFUT Fechamento e CCMFUT Fechamento Predito")
```

In [319…

```
#Cálculo do erro
mse = mean_squared_error(mc_predicao['mc_fechamento'], mc_predicao['mc_fechamento_predi
print('MSE: '+str(mse))
mae = mean_absolute_error(mc_predicao['mc_fechamento'], mc_predicao['mc_fechamento_pred
print('MAE: '+str(mae))
rmse = math.sqrt(mean_squared_error(mc_predicao['mc_fechamento'], mc_predicao['mc_fecha
print('RMSE: '+str(rmse))
```

```
MSE: 0.0002551720660963173
MAE: 0.008955258899856846
RMSE: 0.015974106112591004
```

In [320…

```
mc_df
```

Out[320…

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_volume_fin	ccmfut_fechamento
data						
2008-09-19	2008-09-19	22.64	22.64	22.64	1129500.0	22.64
2008-09-22	2008-09-22	22.64	22.64	22.64	112950.0	22.64
2008-09-26	2008-09-26	22.68	22.68	22.68	565875.0	22.68
2008-09-30	2008-09-30	22.55	22.55	22.55	112500.0	22.55
2008-10-02	2008-10-02	22.64	22.64	22.64	11295.0	22.64
...	...	...	...	...	...	...
2021-02-24	2021-02-24	89.08	89.47	88.42	75830647.5	89.47
2021-02-25	2021-02-25	89.45	89.72	88.81	106361550.0	89.63
2021-02-26	2021-02-26	89.61	89.64	88.86	69200707.5	88.86

	data	ccmfut_abertura	ccmfut_máxima	ccmfut_mínima	ccmfut_volume_fin	ccmfut_fechamento
data						
2021-03-01	2021-03-01	88.92	89.18	88.00	133054398.0	88.70
2021-03-02	2021-03-02	88.80	89.06	88.54	95795617.5	88.94

2916 rows × 9 columns

In [321…

```
mc_df = mc_df.drop(columns='ccmfut_abertura')
mc_df = mc_df.drop(columns='ccmfut_máxima')
mc_df = mc_df.drop(columns='ccmfut_mínima')
mc_df = mc_df.drop(columns='ccmfut_volume_fin')
mc_df = mc_df.drop(columns='milho_reais')
mc_df = mc_df.drop(columns='milho_dolares')
mc_df
```

Out[321…

	data	ccmfut_fechamento	ccmfut_fechamento_alvo
data			
2008-09-19	2008-09-19	22.64	22.64
2008-09-22	2008-09-22	22.64	22.68
2008-09-26	2008-09-26	22.68	22.55
2008-09-30	2008-09-30	22.55	22.64
2008-10-02	2008-10-02	22.64	21.65
...	...	...	...
2021-02-24	2021-02-24	89.47	89.63
2021-02-25	2021-02-25	89.63	88.86
2021-02-26	2021-02-26	88.86	88.70
2021-03-01	2021-03-01	88.70	88.94
2021-03-02	2021-03-02	88.94	91.05

2916 rows × 3 columns

In [322…

```
mc_df_scaled_fech = sc.fit_transform(mc_df.drop(columns = ['data']))
```

In [323…

```
X = mc_df_scaled_fech[:,:1]
y = mc_df_scaled_fech[:,1:]
```

In [324…

```
X = np.asarray(X)
y = np.asarray(y)
```

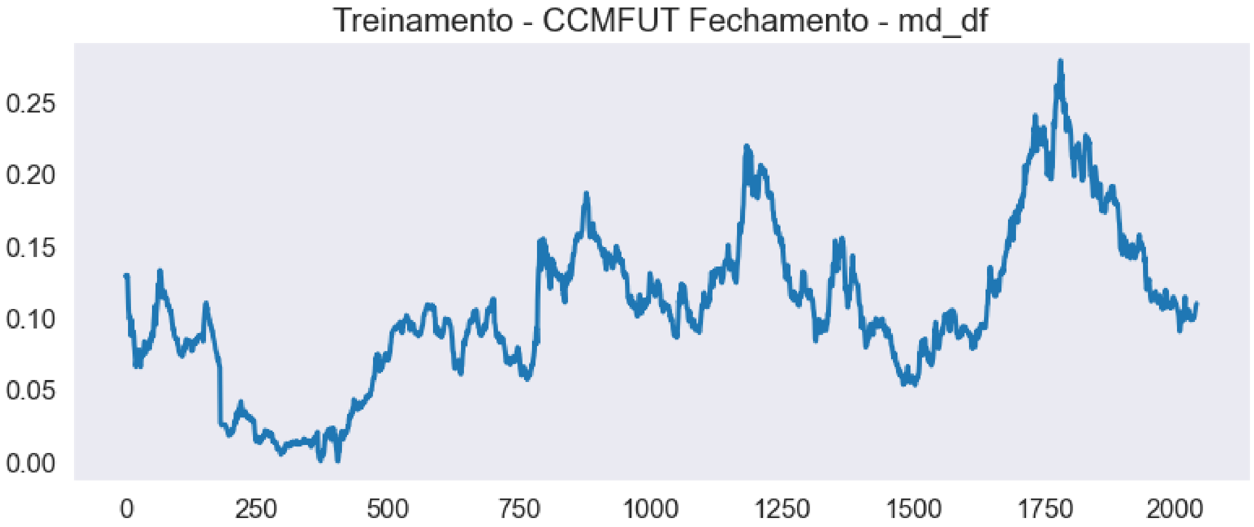
In [325…

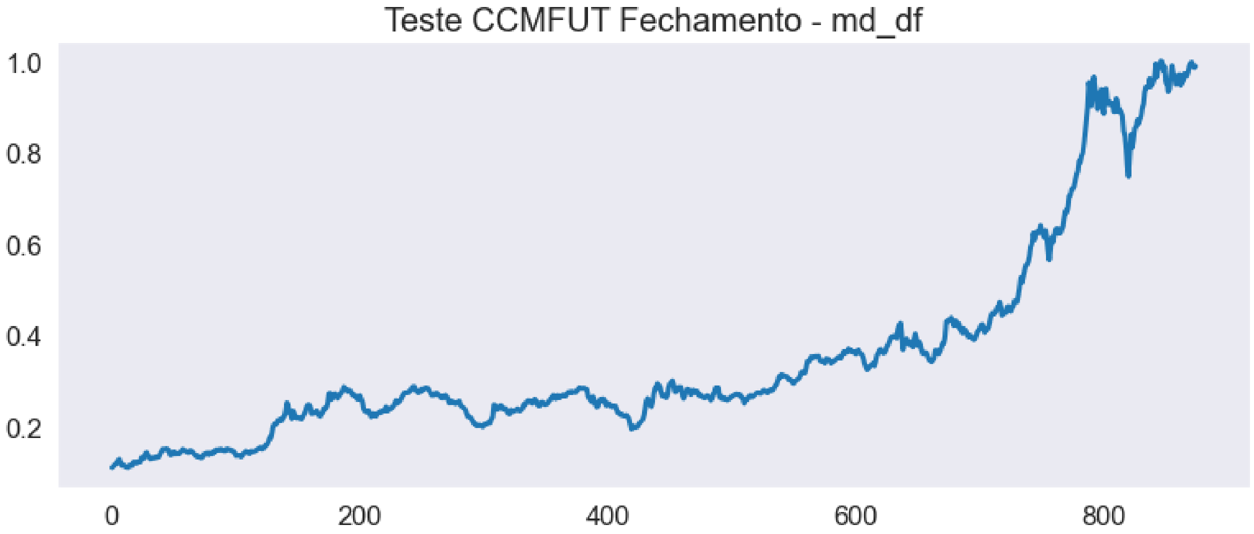
```
split = int(0.70 * len(X))
X_treino = X[:split]
y_treino = y[:split]
```

```
X_teste = X[split:]
y_teste = y[split:]
```

In [326…

```
def show_plot_mc(data, title):
  plt.figure(figsize = (13, 5))
  plt.plot(data, linewidth = 3)
  plt.title(title)
  plt.grid()

show_plot_mc(X_treino, 'Treinamento - CCMFUT Fechamento - md_df')
show_plot_mc(X_teste, 'Teste CCMFUT Fechamento - md_df')
```





In [327…

```
regression_model.fit(X_treino, y_treino)
```

Out[327…

```
Ridge(alpha=1)
```

In [328…

```
lr_accuracy = regression_model.score(X_teste, y_teste)
print("Linear Regression Score: ", lr_accuracy)
```

```
Linear Regression Score:  0.9484580850390733
```

In [329…

```
predicted_prices_mc = regression_model.predict(X)
predicted_prices_mc
```

Out[329…

```
array([[0.12355197],
       [0.12355197],
       [0.12398756],
       ...,
       [0.84466647],
       [0.84292412],
       [0.84553764]])
```

In [330…

```
predicted_mc = []
for i in predicted_prices_mc:
  predicted_mc.append(i[0])
```

In [331…

```
mc_predicao
```

Out[331…

	data	mc_fechamento	mc_fechamento_predito
data			
2008-09-19	2008-09-19	0.128777	0.120601
2008-09-22	2008-09-22	0.128777	0.120452
2008-09-26	2008-09-26	0.129296	0.120939
2008-09-30	2008-09-30	0.127610	0.119349
2008-10-02	2008-10-02	0.128777	0.120427
...	...	...	...
2021-02-24	2021-02-24	0.995461	0.915434
2021-02-25	2021-02-25	0.997536	0.920280
2021-02-26	2021-02-26	0.987550	0.916683
2021-03-01	2021-03-01	0.985475	0.913381
2021-03-02	2021-03-02	0.988588	0.913662

2916 rows × 3 columns

In [332…

```
mc_predicao = mc_predicao.drop(columns='mc_fechamento_predito')
mc_predicao
```

Out[332…

	data	mc_fechamento
data		
2008-09-19	2008-09-19	0.128777
2008-09-22	2008-09-22	0.128777
2008-09-26	2008-09-26	0.129296
2008-09-30	2008-09-30	0.127610
2008-10-02	2008-10-02	0.128777
...	...	...
2021-02-24	2021-02-24	0.995461
2021-02-25	2021-02-25	0.997536

	data	mc_fechamento
data		
2021-02-26	2021-02-26	0.987550
2021-03-01	2021-03-01	0.985475
2021-03-02	2021-03-02	0.988588

2916 rows × 2 columns

In [333...

```
mc_predicao['mc_fechamento_predito'] = predicted_mc
```

In [334...

```
mc_predicao
```

Out[334...

	data	mc_fechamento	mc_fechamento_predito
data			
2008-09-19	2008-09-19	0.128777	0.123552
2008-09-22	2008-09-22	0.128777	0.123552
2008-09-26	2008-09-26	0.129296	0.123988
2008-09-30	2008-09-30	0.127610	0.122572
2008-10-02	2008-10-02	0.128777	0.123552
...	...	...	...
2021-02-24	2021-02-24	0.995461	0.851309
2021-02-25	2021-02-25	0.997536	0.853052
2021-02-26	2021-02-26	0.987550	0.844666
2021-03-01	2021-03-01	0.985475	0.842924
2021-03-02	2021-03-02	0.988588	0.845538

2916 rows × 3 columns

In [335...

```
interactive_plot(mc_predicao, "CCMFUT Fechamento e CCMFUT Fechamento Predito")
```

In [336…

```
#Cálculo do erro
mse = mean_squared_error(mc_predicao['mc_fechamento'], mc_predicao['mc_fechamento_predi
print('MSE: '+str(mse))
mae = mean_absolute_error(mc_predicao['mc_fechamento'], mc_predicao['mc_fechamento_pred
print('MAE: '+str(mae))
rmse = math.sqrt(mean_squared_error(mc_predicao['mc_fechamento'], mc_predicao['mc_fecha
print('RMSE: '+str(rmse))
```

```
MSE: 0.0009740986387099513
MAE: 0.017127976172408
RMSE: 0.03121055332271364
```

In [337…

```
# 5 - RNN - LSTM
```

In [338…

```
mc_df
```

Out[338…

	data	ccmfut_fechamento	ccmfut_fechamento_alvo
data			
2008-09-19	2008-09-19	22.64	22.64
2008-09-22	2008-09-22	22.64	22.68
2008-09-26	2008-09-26	22.68	22.55
2008-09-30	2008-09-30	22.55	22.64
2008-10-02	2008-10-02	22.64	21.65
...	...	...	...
2021-02-24	2021-02-24	89.47	89.63
2021-02-25	2021-02-25	89.63	88.86
2021-02-26	2021-02-26	88.86	88.70
2021-03-01	2021-03-01	88.70	88.94
2021-03-02	2021-03-02	88.94	91.05

2916 rows × 3 columns

In [339…

```
mc_df = mc_df.drop(columns='ccmfut_fechamento_alvo')
mc_df
```

Out[339…

	data	ccmfut_fechamento
data		
2008-09-19	2008-09-19	22.64
2008-09-22	2008-09-22	22.64
2008-09-26	2008-09-26	22.68
2008-09-30	2008-09-30	22.55
2008-10-02	2008-10-02	22.64
...	...	...
2021-02-24	2021-02-24	89.47
2021-02-25	2021-02-25	89.63
2021-02-26	2021-02-26	88.86
2021-03-01	2021-03-01	88.70
2021-03-02	2021-03-02	88.94

2916 rows × 2 columns

In [340…

```
training_data = mc_df.iloc[:, 1:].values
training_data
```

Out[340…

```
array([[22.64],
       [22.64],
       [22.68],
       ...,
       [88.86],
       [88.7 ],
       [88.94]])
```

In [341…

```
from sklearn.preprocessing import MinMaxScaler
sc = MinMaxScaler(feature_range = (0, 1))
training_set_scaled = sc.fit_transform(training_data)
```

In [342…

```
training_set_scaled
```

Out[342…

```
array([[0.12877707],
       [0.12877707],
       [0.12929581],
       ...,
       [0.98755025],
       [0.9854753 ],
       [0.98858773]])
```

In [343…

```
X = []
y = []
for i in range(1, len(mc_df)):
    X.append(training_set_scaled [i-1:i, 0])
    y.append(training_set_scaled [i, 0])
```

```
In [344…  X
```

```
Out[344…  [array([0.12877707]),
           array([0.12877707]),
           array([0.12929581]),
           array([0.12760991]),
           array([0.12877707]),
           array([0.11593827]),
           array([0.10647127]),
           array([0.10076514]),
           array([0.09830113]),
           array([0.10063546]),
           array([0.0874076]),
           array([0.09843081]),
           array([0.09246531]),
           array([0.09013098]),
           array([0.08896382]),
           array([0.09013098]),
           array([0.08727791]),
           array([0.08079367]),
           array([0.07729218]),
           array([0.0719751]),
           array([0.06562054]),
           array([0.06912203]),
           array([0.06912203]),
           array([0.06795487]),
           array([0.0719751]),
           array([0.07262352]),
           array([0.07729218]),
           array([0.07145636]),
           array([0.06678771]),
           array([0.06562054]),
           array([0.0702892]),
           array([0.07612502]),
           array([0.07262352]),
           array([0.07495785]),
           array([0.07392037]),
           array([0.07962651]),
           array([0.083128]),
           array([0.08260926]),
           array([0.07495785]),
           array([0.07962651]),
           array([0.08196084]),
           array([0.08079367]),
           array([0.07975619]),
           array([0.08092336]),
           array([0.08196084]),
           array([0.08079367]),
           array([0.07845934]),
           array([0.0814421]),
           array([0.08611075]),
           array([0.08377642]),
           array([0.0874076]),
           array([0.08974193]),
           array([0.08662949]),
           array([0.08675918]),
           array([0.0959668]),
           array([0.10050577]),
           array([0.10673064]),
           array([0.10828686]),
           array([0.09479964]),
           array([0.10296978]),
           array([0.10776812]),
           array([0.1113993]),
           array([0.12294125]),
           array([0.11593827]),
           array([0.12060693]),
           array([0.12644274]),
           array([0.1327973]),
           array([0.12877707]),
           array([0.12760991]),
           array([0.12177409]),
           array([0.11360394]),
           array([0.11477111]),
           array([0.11710543]),
           array([0.11528985]),
           array([0.1182726]),
           array([0.11593827]),
           array([0.11373363]),
           array([0.11295552]),
           array([0.11243678]),
           array([0.11295552]),
           array([0.10776812]),
           array([0.10776812]),
           array([0.10893529]),
           array([0.10776812]),
           array([0.10530411]),
           array([0.10361821]),
           array([0.10478537]),
           array([0.10180262]),
           array([0.09830113]),
           array([0.0959668]),
           array([0.09363247]),
           array([0.09129815]),
           array([0.09194657]),
           array([0.08779665]),
           array([0.08611075]),
           array([0.08546233]),
           array([0.08546233]),
           array([0.08429516]),
           array([0.08546233]),
           array([0.0814421]),
           array([0.0805343]),
           array([0.07910777]),
           array([0.07612502]),
           array([0.07547659]),
           array([0.07430943]),
           array([0.07495785]),
           array([0.07547659]),
           array([0.07379069]),
           array([0.07275321]),
           array([0.07327195]),
           array([0.07443911]),
           array([0.0771625]),
           array([0.08001556]),
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 0.1174944883932045,
 0.12449747114511736,
 0.1305926598365971,
 0.1287770717157308,
 ...]
```

In [346…

```
X = np.asarray(X)
y = np.asarray(y)
```

In [347…

```
X.shape , y.shape
```

Out[347…

```
((2915, 1), (2915,))
```

In [348…

```
split = int(0.7 * len(X))
X_train = X[:split]
y_train = y[:split]
X_test = X[split:]
y_test = y[split:]
```

In [349…

```
X_train.shape , y_train.shape, X_test.shape, y_test.shape
```

Out[349…

```
((2040, 1), (2040,), (875, 1), (875,))
```

In [350…

```
X_train = np.reshape(X_train, (X_train.shape[0], X_train.shape[1], 1))
X_test = np.reshape(X_test, (X_test.shape[0], X_test.shape[1], 1))
X_train.shape, X_test.shape
```

Out[350…

```
((2040, 1, 1), (875, 1, 1))
```

In [351…

```
X_train
```

Out[351…

```
array([[[0.12877707]],

       [[0.12877707]],

       [[0.12929581]],

       ...,

       [[0.10361821]],

       [[0.1054338 ]],

       [[0.10815718]]])
```

In [352…

```
X_train.shape
```

Out[352…

```
(2040, 1, 1)
```

In [353…

```
inputs = keras.layers.Input(shape=(X_train.shape[1], X_train.shape[2]))
x = keras.layers.LSTM(150, return_sequences= True)(inputs)
x = keras.layers.Dropout(0.3)(x)
x = keras.layers.LSTM(150, return_sequences=True)(x)
x = keras.layers.Dropout(0.3)(x)
x = keras.layers.LSTM(150)(x)
outputs = keras.layers.Dense(1, activation='linear')(x)

model = keras.Model(inputs=inputs, outputs=outputs)
model.compile(optimizer='adam', loss="mse")
model.summary()
```

```
Model: "model_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
input_3 (InputLayer)         [(None, 1, 1)]            0         
_________________________________________________________________
lstm_6 (LSTM)                (None, 1, 150)            91200     
_________________________________________________________________
dropout_4 (Dropout)          (None, 1, 150)            0         
_________________________________________________________________
lstm_7 (LSTM)                (None, 1, 150)            180600    
```

```
_________________________________________________________________
dropout_5 (Dropout)          (None, 1, 150)            0
_________________________________________________________________
lstm_8 (LSTM)                (None, 150)               180600
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 151
=================================================================
Total params: 452,551
Trainable params: 452,551
Non-trainable params: 0
_________________________________________________________________
```

In [354…

```
X_train.shape, y_train.shape
```

Out[354…

```
((2040, 1, 1), (2040,))
```

In [355…

```
history = model.fit(
    X_train, y_train,
    epochs = 20,
    batch_size = 32,
    validation_split = 0.2
)
```

```
Epoch 1/20
51/51 [==============================] - 3s 51ms/step - loss: 0.0030 - val_loss: 0.0057
Epoch 2/20
51/51 [==============================] - 1s 11ms/step - loss: 0.0010 - val_loss: 4.1449e
-05
Epoch 3/20
51/51 [==============================] - 1s 11ms/step - loss: 6.6296e-05 - val_loss: 2.5
949e-05
Epoch 4/20
51/51 [==============================] - 1s 11ms/step - loss: 4.0457e-05 - val_loss: 2.4
025e-05
Epoch 5/20
51/51 [==============================] - 0s 10ms/step - loss: 3.9753e-05 - val_loss: 3.7
790e-05
Epoch 6/20
51/51 [==============================] - 1s 10ms/step - loss: 4.1150e-05 - val_loss: 2.5
174e-05
Epoch 7/20
51/51 [==============================] - 0s 8ms/step - loss: 3.2069e-05 - val_loss: 4.03
90e-05
Epoch 8/20
51/51 [==============================] - 0s 9ms/step - loss: 3.2752e-05 - val_loss: 2.46
66e-05
Epoch 9/20
51/51 [==============================] - 0s 8ms/step - loss: 3.4260e-05 - val_loss: 2.85
44e-05
Epoch 10/20
51/51 [==============================] - 0s 7ms/step - loss: 3.5984e-05 - val_loss: 2.34
59e-05
Epoch 11/20
51/51 [==============================] - 0s 7ms/step - loss: 3.1575e-05 - val_loss: 2.97
29e-05
Epoch 12/20
51/51 [==============================] - 0s 8ms/step - loss: 3.0410e-05 - val_loss: 3.67
40e-05
Epoch 13/20
51/51 [==============================] - 0s 9ms/step - loss: 3.1194e-05 - val_loss: 2.87
55e-05
Epoch 14/20
51/51 [==============================] - 0s 8ms/step - loss: 2.9855e-05 - val_loss: 2.99
55e-05
```

```
Epoch 15/20
51/51 [==============================] - 0s 7ms/step - loss: 3.0825e-05 - val_loss: 2.44
23e-05
Epoch 16/20
51/51 [==============================] - 0s 9ms/step - loss: 2.8862e-05 - val_loss: 2.40
80e-05
Epoch 17/20
51/51 [==============================] - 0s 8ms/step - loss: 3.6636e-05 - val_loss: 2.47
57e-05
Epoch 18/20
51/51 [==============================] - 0s 8ms/step - loss: 3.3046e-05 - val_loss: 2.37
31e-05
Epoch 19/20
51/51 [==============================] - 0s 8ms/step - loss: 2.9455e-05 - val_loss: 2.38
31e-05
Epoch 20/20
51/51 [==============================] - 0s 8ms/step - loss: 3.6684e-05 - val_loss: 4.77
91e-05
```

In [356...
```
predicted_LSTM = model.predict(X)
```

In [357...
```
predicted_LSTM
```

Out[357...
```
array([[0.12406403],
       [0.12406403],
       [0.12458012],
       ...,
       [0.9513022 ],
       [0.9426287 ],
       [0.9408232 ]], dtype=float32)
```

In [358...
```
predicted.shape
```

Out[358...
```
(2915, 1)
```

In [359...
```
test_predicted_LSTM = []

for i in predicted_LSTM:
  test_predicted_LSTM.append(i[0])
```

In [360...
```
len(test_predicted_LSTM)
```

Out[360...
```
2915
```

In [361...
```
df_predicao_LSTM = pd.DataFrame(columns = ['data' , 'Fechamento', 'Fechamento_Predito']
```

In [362...
```
df_predicao_LSTM
```

Out[362...

data	Fechamento	Fechamento_Predito

In [363...
```
df_predicao_LSTM['data'] = mc_df[1:]['data']
```

In [364...
```
df_predicao_LSTM
```

Out[364...

	data	Fechamento	Fechamento_Predito
data			

	data	Fechamento	Fechamento_Predito
data			
2008-09-22	2008-09-22	NaN	NaN
2008-09-26	2008-09-26	NaN	NaN
2008-09-30	2008-09-30	NaN	NaN
2008-10-02	2008-10-02	NaN	NaN
2008-10-03	2008-10-03	NaN	NaN
...	...	...	...
2021-02-24	2021-02-24	NaN	NaN
2021-02-25	2021-02-25	NaN	NaN
2021-02-26	2021-02-26	NaN	NaN
2021-03-01	2021-03-01	NaN	NaN
2021-03-02	2021-03-02	NaN	NaN

2915 rows × 3 columns

In [365…

```
Fechamento_Scaled = []
for i in training_set_scaled:
  Fechamento_Scaled.append(i[0])
```

In [366…

```
len(Fechamento_Scaled)
```

Out[366…

```
2916
```

In [367…

```
df_predicao_LSTM
```

Out[367…

	data	Fechamento	Fechamento_Predito
data			
2008-09-22	2008-09-22	NaN	NaN
2008-09-26	2008-09-26	NaN	NaN
2008-09-30	2008-09-30	NaN	NaN
2008-10-02	2008-10-02	NaN	NaN
2008-10-03	2008-10-03	NaN	NaN
...	...	...	...
2021-02-24	2021-02-24	NaN	NaN
2021-02-25	2021-02-25	NaN	NaN
2021-02-26	2021-02-26	NaN	NaN
2021-03-01	2021-03-01	NaN	NaN
2021-03-02	2021-03-02	NaN	NaN

2915 rows × 3 columns

In [368…
```
df_predicao_LSTM['Fechamento'] = Fechamento_Scaled[1:]
```

In [369…
```
df_predicao_LSTM
```

Out[369…

	data	Fechamento	Fechamento_Predito
data			
2008-09-22	2008-09-22	0.128777	NaN
2008-09-26	2008-09-26	0.129296	NaN
2008-09-30	2008-09-30	0.127610	NaN
2008-10-02	2008-10-02	0.128777	NaN
2008-10-03	2008-10-03	0.115938	NaN
...	...	...	...
2021-02-24	2021-02-24	0.995461	NaN
2021-02-25	2021-02-25	0.997536	NaN
2021-02-26	2021-02-26	0.987550	NaN
2021-03-01	2021-03-01	0.985475	NaN
2021-03-02	2021-03-02	0.988588	NaN

2915 rows × 3 columns

In [370…
```
df_predicao_LSTM['Fechamento_Predito'] = test_predicted_LSTM
```

In [371…
```
df_predicao_LSTM
```

Out[371…

	data	Fechamento	Fechamento_Predito
data			
2008-09-22	2008-09-22	0.128777	0.124064
2008-09-26	2008-09-26	0.129296	0.124064
2008-09-30	2008-09-30	0.127610	0.124580
2008-10-02	2008-10-02	0.128777	0.122903
2008-10-03	2008-10-03	0.115938	0.124064
...	...	...	...
2021-02-24	2021-02-24	0.995461	0.944320
2021-02-25	2021-02-25	0.997536	0.949502
2021-02-26	2021-02-26	0.987550	0.951302
2021-03-01	2021-03-01	0.985475	0.942629
2021-03-02	2021-03-02	0.988588	0.940823

2915 rows × 3 columns

In [372…

```
interactive_plot(df_predicao_LSTM, "LSTM - CCMFUT Fechamento e CCMFUT Fechamento Predit
```

In [373…

```
#Cálculo do erro
mse = mean_squared_error(df_predicao_LSTM['Fechamento'], df_predicao_LSTM['Fechamento_P
print('MSE: '+str(mse))
mae = mean_absolute_error(df_predicao_LSTM['Fechamento'], df_predicao_LSTM['Fechamento_
print('MAE: '+str(mae))
rmse = math.sqrt(mean_squared_error(df_predicao_LSTM['Fechamento'], df_predicao_LSTM['F
print('RMSE: '+str(rmse))
```

```
MSE: 0.00011615309602060521
MAE: 0.0069011389543802695
RMSE: 0.010777434575102055
```

In [ ]: