Aplicação de Análise Estatística Descritiva no Mercado Financeiro

July 26, 2022

0.1 Aplicação de Análise Estatística Descritiva no Mercado Financeiro

0.2 Importando as Bibliotecas

[ ]:
```
import math

import requests

import numpy as np
import pandas as pd
import seaborn as sns
import plotly.express as px
import matplotlib.pyplot as plt

from scipy import stats
from scipy import optimize
from pandas_datareader import data

from alive_progress import alive_bar
```

0.2.1 Construindo uma Base de Dados Financeiros com Ações Do Mercado De Criptoativos

[ ]:
```
ativos = {"BITCOIN": "BTC", "CARDANO": "ADA", "LITECOIN": "LTC", "CHILIZ":␣
 ↪"CHZ", "USDC": "USDC", "NANO": "LINK"}
anos = [2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022]
meses = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]
dias = list(range(1, 32))
```

[ ]:
```
resumo_ativos = []
url_resumo_diario = "https://www.mercadobitcoin.net/api/{ativo}/day-summary/
 ↪{ano}/{mes}/{dia}/"

for ativo in ativos.values():
    print(ativo)
    resumo_ativo = []
    for ano in anos:
        print(ano)
```

```
        for mes in meses:
            # pular os meses futuros do ano de 2022
            if ano == 2022 and mes > 7:
                continue
            for dia in dias:
                # pular os dias futuros de julho de 2022
                if ano == 2022 and mes == 7 and dia >= 25:
                    continue
                url_dia_formatada = url_resumo_diario.
↪format(ativo=ativo,ano=ano, mes=mes, dia=dia)
                resposta = requests.get(url=url_dia_formatada)
                if resposta.status_code == 200:
                    resumo_ativo.append(resposta.json())
                else:
                    continue
    resumo_ativos.append(resumo_ativo)
```

[ ]:
```
resumo_ativos
```

[234]:
```
acoes_df = pd.DataFrame()

for ativo, resumo in zip(ativos, resumo_ativos):
    indice = [r["date"] for r in resumo]
    acoes_df[ativo] = pd.DataFrame(resumo)["closing"]

acoes_df["Date"] = [r["date"] for r in resumo_ativos[0]]
# acoes_df.fillna(0, inplace=True)
acoes_df
```

[234]:

	BITCOIN	CARDANO	LITECOIN	CHILIZ	USDC	NANO	\
0	880.100050	12.89956	8.21562	0.07000	5.44500	60.37949	
1	921.847150	12.43990	8.39407	0.06800	5.38850	62.54979	
2	810.010000	12.40000	6.50000	0.06540	5.46790	64.27989	
3	848.999990	12.33131	6.02040	0.06510	5.44001	65.48000	
4	788.000000	12.07408	6.37030	0.06439	5.39874	65.57001	
…	…	…	…	…	…	…	
2809	125000.000000	NaN	313.65668	NaN	NaN	NaN	
2810	126708.000000	NaN	311.61799	NaN	NaN	NaN	
2811	126017.000000	NaN	NaN	NaN	NaN	NaN	
2812	124115.769950	NaN	NaN	NaN	NaN	NaN	
2813	121148.148952	NaN	NaN	NaN	NaN	NaN	

	Date
0	2015-01-01
1	2015-01-02
2	2015-01-03
3	2015-01-04

```
4     2015-01-05
…          …
2809  2022-07-20
2810  2022-07-21
2811  2022-07-22
2812  2022-07-23
2813  2022-07-24

[2814 rows x 7 columns]
```

0.2.2 Visualização dos Dados

[235]:
```
figura = px.line(title = "Histórico do preço das ações")
for ativo in acoes_df.columns[:-1]:
  figura.add_scatter(x=acoes_df["Date"], y=acoes_df[ativo], name=ativo)
figura.show()
```

Taxa de Retorno de Ações

$$\mathbb{E}[R_i] = \log(\frac{P_t}{P_{t-1}}) \tag{1}$$

[236]:
```
dataset = acoes_df.copy()
dataset
```

[236]:
```
            BITCOIN   CARDANO   LITECOIN   CHILIZ     USDC      NANO  \
0        880.100050  12.89956    8.21562  0.07000  5.44500  60.37949
1        921.847150  12.43990    8.39407  0.06800  5.38850  62.54979
2        810.010000  12.40000    6.50000  0.06540  5.46790  64.27989
3        848.999990  12.33131    6.02040  0.06510  5.44001  65.48000
4        788.000000  12.07408    6.37030  0.06439  5.39874  65.57001
…              …       …          …        …        …        …
2809  125000.000000       NaN  313.65668      NaN      NaN      NaN
2810  126708.000000       NaN  311.61799      NaN      NaN      NaN
2811  126017.000000       NaN        NaN      NaN      NaN      NaN
2812  124115.769950       NaN        NaN      NaN      NaN      NaN
2813  121148.148952       NaN        NaN      NaN      NaN      NaN

            Date
0     2015-01-01
1     2015-01-02
2     2015-01-03
3     2015-01-04
4     2015-01-05
…          …
2809  2022-07-20
```

```
2810  2022-07-21
2811  2022-07-22
2812  2022-07-23
2813  2022-07-24

[2814 rows x 7 columns]
```

[237]:
```
dataset.drop(labels = ['Date'], axis=1, inplace=True)
dataset
```

[237]:
```
            BITCOIN   CARDANO   LITECOIN   CHILIZ     USDC      NANO
0        880.100050  12.89956    8.21562  0.07000  5.44500  60.37949
1        921.847150  12.43990    8.39407  0.06800  5.38850  62.54979
2        810.010000  12.40000    6.50000  0.06540  5.46790  64.27989
3        848.999990  12.33131    6.02040  0.06510  5.44001  65.48000
4        788.000000  12.07408    6.37030  0.06439  5.39874  65.57001
…              …       …          …        …        …        …
2809  125000.000000       NaN  313.65668      NaN      NaN      NaN
2810  126708.000000       NaN  311.61799      NaN      NaN      NaN
2811  126017.000000       NaN        NaN      NaN      NaN      NaN
2812  124115.769950       NaN        NaN      NaN      NaN      NaN
2813  121148.148952       NaN        NaN      NaN      NaN      NaN

[2814 rows x 6 columns]
```

[238]:
```
dataset.shift(1)
```

[238]:
```
            BITCOIN   CARDANO   LITECOIN  CHILIZ     USDC      NANO
0               NaN       NaN        NaN     NaN      NaN       NaN
1         880.10005  12.89956    8.21562  0.0700  5.44500  60.37949
2         921.84715  12.43990    8.39407  0.0680  5.38850  62.54979
3         810.01000  12.40000    6.50000  0.0654  5.46790  64.27989
4         848.99999  12.33131    6.02040  0.0651  5.44001  65.48000
…               …       …          …        …        …        …
2809  127065.22928       NaN  311.44263      NaN      NaN      NaN
2810  125000.00000       NaN  313.65668      NaN      NaN      NaN
2811  126708.00000       NaN  311.61799      NaN      NaN      NaN
2812  126017.00000       NaN        NaN      NaN      NaN      NaN
2813  124115.76995       NaN        NaN      NaN      NaN      NaN

[2814 rows x 6 columns]
```

[239]:
```
taxas_retorno = np.log(dataset / dataset.shift(1))
taxas_retorno
```

[239]:
```
       BITCOIN   CARDANO  LITECOIN    CHILIZ      USDC      NANO
0          NaN       NaN       NaN       NaN       NaN       NaN
```

```
1     0.046344 -0.036284  0.021488 -0.028988 -0.010431  0.035313
2    -0.129333 -0.003213 -0.255723 -0.038985  0.014628  0.027284
3     0.047013 -0.005555 -0.076648 -0.004598 -0.005114  0.018498
4    -0.074561 -0.021081  0.056493 -0.010966 -0.007615  0.001374
…          …       …        …        …        …        …
2809 -0.016387       NaN  0.007084       NaN       NaN       NaN
2810  0.013571       NaN -0.006521       NaN       NaN       NaN
2811 -0.005468       NaN       NaN       NaN       NaN       NaN
2812 -0.015202       NaN       NaN       NaN       NaN       NaN
2813 -0.024201       NaN       NaN       NaN       NaN       NaN

[2814 rows x 6 columns]
```

[240]:
```
taxas_retorno.describe()
```

[240]:
```
           BITCOIN     CARDANO     LITECOIN      CHILIZ        USDC  \
count  2813.000000  296.000000  2810.000000  754.000000  804.000000
mean      0.001751   -0.005255     0.001294    0.002804    0.000014
std       0.036786    0.049907     0.056861    0.081998    0.010333
min      -0.338736   -0.273860    -0.416640   -0.507883   -0.058051
25%      -0.012420   -0.035786    -0.023377   -0.030629   -0.005783
50%       0.001301   -0.007014     0.000346    0.000154    0.000000
75%       0.018018    0.023472     0.023323    0.032850    0.005611
max       0.224670    0.131900     0.500463    0.663503    0.040221

             NANO
count  603.000000
mean    -0.000802
std      0.061187
min     -0.362016
25%     -0.037127
50%      0.000878
75%      0.036673
max      0.202124
```

[249]:
```
medias = (taxas_retorno[list(ativos.keys())].sum()/
 ↪len(taxas_retorno[list(ativos.keys())]))*100
medias
```

[249]:
```
BITCOIN     0.175008
CARDANO    -0.055274
LITECOIN    0.129202
CHILIZ      0.075143
USDC        0.000403
NANO       -0.017181
dtype: float64
```

[250]:
```
taxas_retorno.mean()*100
```

[250]:
```
BITCOIN     0.175071
CARDANO    -0.525479
LITECOIN    0.129386
CHILIZ      0.280442
USDC        0.001409
NANO       -0.080178
dtype: float64
```

[252]:
```
vars_acoes = ((taxas_retorno[list(ativos.keys())] - taxas_retorno.mean()) ** 2).
↪sum() / (len(taxas_retorno[list(ativos.keys())]) - 1)
vars_acoes
```

[252]:
```
BITCOIN     0.001353
CARDANO     0.000261
LITECOIN    0.003229
CHILIZ      0.001800
USDC        0.000030
NANO        0.000801
dtype: float64
```

[253]:
```
taxas_retorno.var()
```

[253]:
```
BITCOIN     0.001353
CARDANO     0.002491
LITECOIN    0.003233
CHILIZ      0.006724
USDC        0.000107
NANO        0.003744
dtype: float64
```

[254]:
```
taxas_retorno.std()*100
```

[254]:
```
BITCOIN     3.678649
CARDANO     4.990717
LITECOIN    5.686067
CHILIZ      8.199754
USDC        1.033278
NANO        6.118684
dtype: float64
```

[255]:
```
dataset_date = acoes_df.copy()
date = dataset_date.filter(["Date"])
date
```

[255]:
```
            Date
0     2015-01-01
1     2015-01-02
2     2015-01-03
3     2015-01-04
4     2015-01-05
…          …
2809  2022-07-20
2810  2022-07-21
2811  2022-07-22
2812  2022-07-23
2813  2022-07-24

[2814 rows x 1 columns]
```

[256]:
```
taxas_retorno_date = pd.concat([date, taxas_retorno], axis=1)
taxas_retorno_date
```

[256]:
```
            Date   BITCOIN   CARDANO  LITECOIN    CHILIZ      USDC      NANO
0     2015-01-01       NaN       NaN       NaN       NaN       NaN       NaN
1     2015-01-02  0.046344 -0.036284  0.021488 -0.028988 -0.010431  0.035313
2     2015-01-03 -0.129333 -0.003213 -0.255723 -0.038985  0.014628  0.027284
3     2015-01-04  0.047013 -0.005555 -0.076648 -0.004598 -0.005114  0.018498
4     2015-01-05 -0.074561 -0.021081  0.056493 -0.010966 -0.007615  0.001374
…          …       …       …       …       …       …       …
2809  2022-07-20 -0.016387       NaN  0.007084       NaN       NaN       NaN
2810  2022-07-21  0.013571       NaN -0.006521       NaN       NaN       NaN
2811  2022-07-22 -0.005468       NaN       NaN       NaN       NaN       NaN
2812  2022-07-23 -0.015202       NaN       NaN       NaN       NaN       NaN
2813  2022-07-24 -0.024201       NaN       NaN       NaN       NaN       NaN

[2814 rows x 7 columns]
```

[258]:
```
figura = px.line(title = 'Histórico de retorno das ações')
for i in taxas_retorno_date.columns[1:]:
  figura.add_scatter(x = taxas_retorno_date["Date"] ,y = taxas_retorno_date[i],␣
 ↪name = i)
figura.show()
```

[259]:
```
taxas_retorno.cov()
```

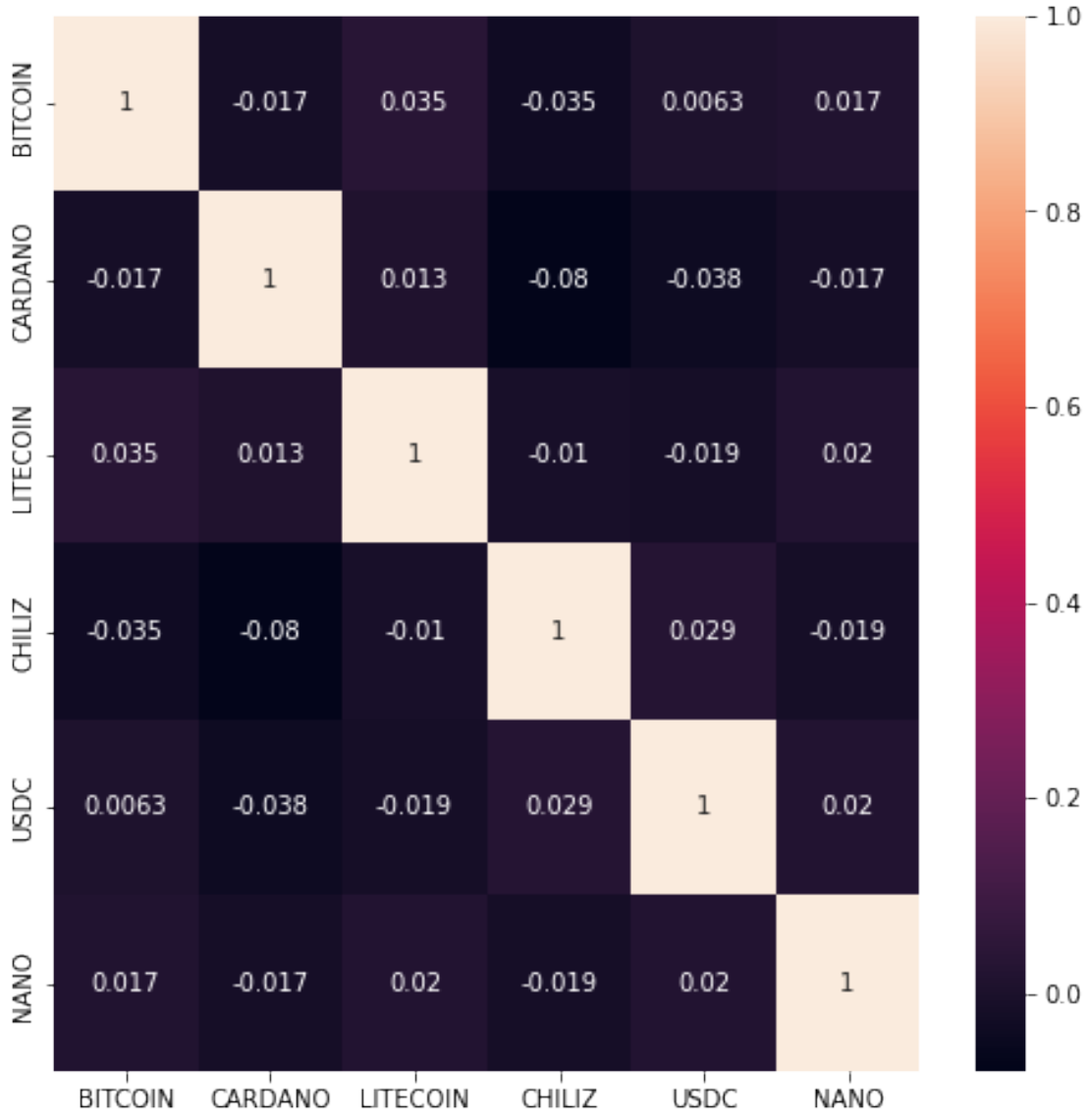
[259]:
```
            BITCOIN   CARDANO  LITECOIN    CHILIZ      USDC      NANO
BITCOIN    0.001353 -0.000028  0.000073 -0.000092  0.000002  0.000035
CARDANO   -0.000028  0.002491  0.000050 -0.000403 -0.000022 -0.000058
LITECOIN   0.000073  0.000050  0.003233 -0.000050 -0.000011  0.000077
CHILIZ    -0.000092 -0.000403 -0.000050  0.006724  0.000025 -0.000099
USDC       0.000002 -0.000022 -0.000011  0.000025  0.000107  0.000013
```

```
NANO      0.000035 -0.000058  0.000077 -0.000099  0.000013  0.003744
```

[260]:
```
taxas_retorno.corr()
```

[260]:
```
           BITCOIN   CARDANO  LITECOIN    CHILIZ      USDC      NANO
BITCOIN   1.000000 -0.016890  0.034717 -0.034754  0.006280  0.017157
CARDANO  -0.016890  1.000000  0.012622 -0.079718 -0.038034 -0.017095
LITECOIN  0.034717  0.012622  1.000000 -0.010169 -0.019006  0.019868
CHILIZ   -0.034754 -0.079718 -0.010169  1.000000  0.028713 -0.018692
USDC      0.006280 -0.038034 -0.019006  0.028713  1.000000  0.019841
NANO      0.017157 -0.017095  0.019868 -0.018692  0.019841  1.000000
```

[261]:
```
plt.figure(figsize=(8,8))
sns.heatmap(taxas_retorno.corr(), annot=True);
```



Montando uma Carteira de Ativos

[262]:
```
taxas_retorno_date["CARTEIRA"] = (taxas_retorno_date["BITCOIN"] +␣
 ↪taxas_retorno_date["CARDANO"] +
                                  taxas_retorno_date["LITECOIN"] +␣
 ↪taxas_retorno_date["CHILIZ"] +
                                  taxas_retorno_date["USDC"])/5
taxas_retorno_date
```

[262]:

	Date	BITCOIN	CARDANO	LITECOIN	CHILIZ	USDC	NANO	CARTEIRA
0	2015-01-01	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	2015-01-02	0.046344	-0.036284	0.021488	-0.028988	-0.010431	0.035313	-0.001574
2	2015-01-03	-0.129333	-0.003213	-0.255723	-0.038985	0.014628	0.027284	-0.082525
3	2015-01-04	0.047013	-0.005555	-0.076648	-0.004598	-0.005114	0.018498	-0.008980
4	2015-01-05	-0.074561	-0.021081	0.056493	-0.010966	-0.007615	0.001374	-0.011546
…	…	…	…	…	…	…	…	…
2809	2022-07-20	-0.016387	NaN	0.007084	NaN	NaN	NaN	NaN
2810	2022-07-21	0.013571	NaN	-0.006521	NaN	NaN	NaN	NaN
2811	2022-07-22	-0.005468	NaN	NaN	NaN	NaN	NaN	NaN
2812	2022-07-23	-0.015202	NaN	NaN	NaN	NaN	NaN	NaN
2813	2022-07-24	-0.024201	NaN	NaN	NaN	NaN	NaN	NaN

[2814 rows x 8 columns]

[263]:
```
taxas_retorno_port = taxas_retorno_date.filter(["Date", "CARTEIRA", "NANO"])
taxas_retorno_port
```

[263]:

	Date	CARTEIRA	NANO
0	2015-01-01	NaN	NaN
1	2015-01-02	-0.001574	0.035313
2	2015-01-03	-0.082525	0.027284
3	2015-01-04	-0.008980	0.018498

```
4     2015-01-05 -0.011546  0.001374
…            …        …        …
2809  2022-07-20       NaN       NaN
2810  2022-07-21       NaN       NaN
2811  2022-07-22       NaN       NaN
2812  2022-07-23       NaN       NaN
2813  2022-07-24       NaN       NaN

[2814 rows x 3 columns]
```

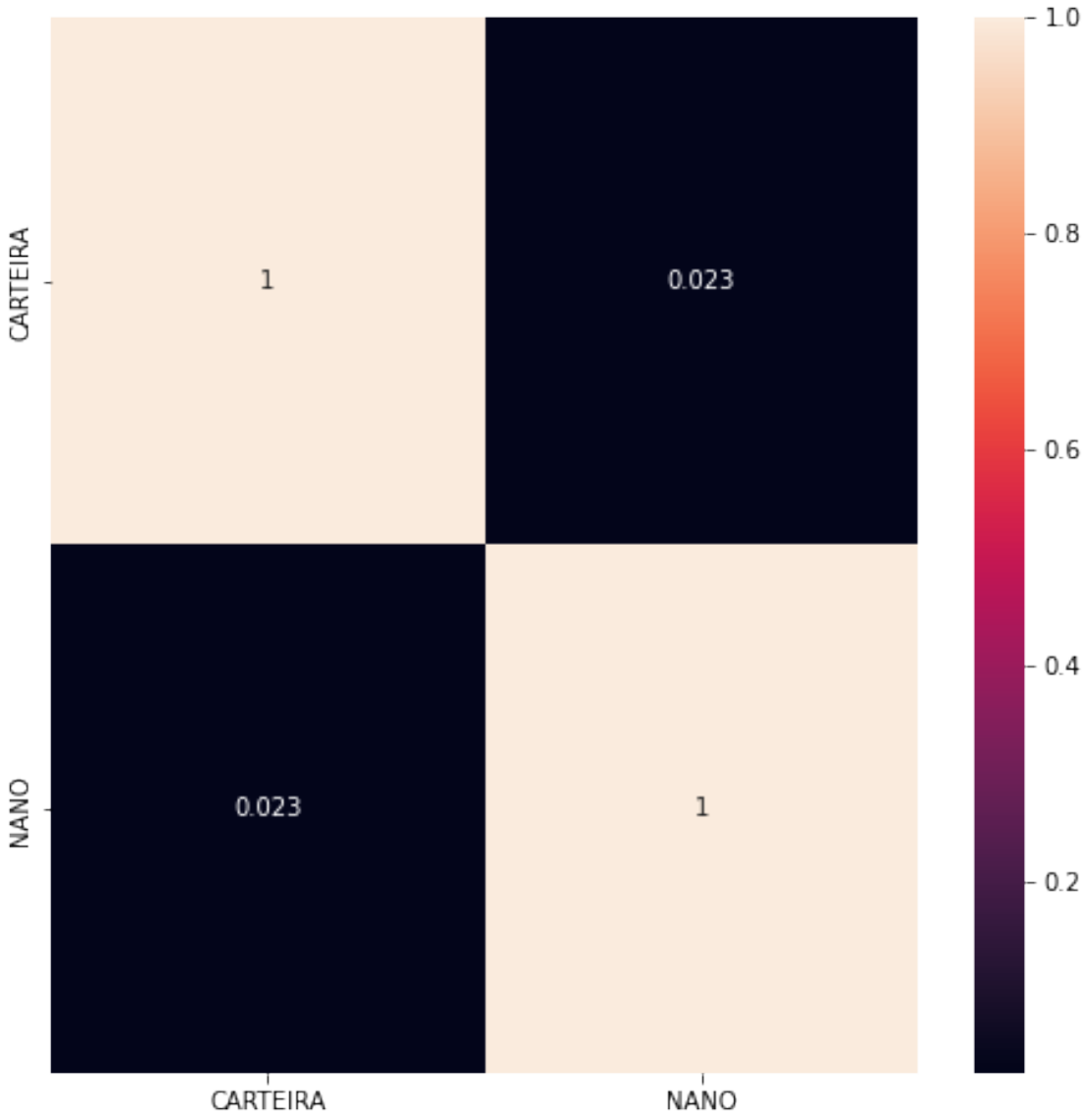
[264]:
```
figura = px.line(title = 'Comparação de retorno Carteira x Ativo Nano')
for i in taxas_retorno_port.columns[1:]:
  figura.add_scatter(x = taxas_retorno_port["Date"] ,y = taxas_retorno_port[i],␣
 ↪name = i)
figura.add_hline(y = taxas_retorno_port['CARTEIRA'].mean(), line_color="green",␣
 ↪line_dash="dot", )
figura.show()
```

[266]:
```
taxas_retorno_port_corr = taxas_retorno_date.filter(["CARTEIRA", "NANO"])
taxas_retorno_port_corr
```

[266]:
```
      CARTEIRA      NANO
0          NaN       NaN
1    -0.001574  0.035313
2    -0.082525  0.027284
3    -0.008980  0.018498
4    -0.011546  0.001374
…          …         …
2809       NaN       NaN
2810       NaN       NaN
2811       NaN       NaN
2812       NaN       NaN
2813       NaN       NaN

[2814 rows x 2 columns]
```

[267]:
```
plt.figure(figsize=(8,8))
sns.heatmap(taxas_retorno_port_corr.corr(), annot=True);
```



[268]:
```
#### Alocação Aleatória de Ativos - Portfólio Markowitz
```

[269]:
```
acoes_port = acoes_df.copy()
acoes_port.drop(labels = ["NANO"], axis=1, inplace=True)
acoes_port
```

[269]:

	BITCOIN	CARDANO	LITECOIN	CHILIZ	USDC	Date
0	880.100050	12.89956	8.21562	0.07000	5.44500	2015-01-01
1	921.847150	12.43990	8.39407	0.06800	5.38850	2015-01-02
2	810.010000	12.40000	6.50000	0.06540	5.46790	2015-01-03
3	848.999990	12.33131	6.02040	0.06510	5.44001	2015-01-04
4	788.000000	12.07408	6.37030	0.06439	5.39874	2015-01-05

```
...              ...       ...         ...       ...       ...         ...
2809  125000.000000       NaN  313.65668       NaN       NaN  2022-07-20
2810  126708.000000       NaN  311.61799       NaN       NaN  2022-07-21
2811  126017.000000       NaN         NaN       NaN       NaN  2022-07-22
2812  124115.769950       NaN         NaN       NaN       NaN  2022-07-23
2813  121148.148952       NaN         NaN       NaN       NaN  2022-07-24

[2814 rows x 6 columns]
```

[277]:
```
def alocacao_ativos(dataset, dinheiro_total, seed = 0, melhores_pesos = []):
  dataset = dataset.copy()

  if seed != 0:
    np.random.seed(seed)

  if len(melhores_pesos) > 0:
    pesos = melhores_pesos
  else:
    pesos = np.random.random(len(dataset.columns) - 1)
    pesos = pesos / pesos.sum()

  colunas = dataset.columns[:-1]
  for i in colunas:
    dataset[i] = (dataset[i] / dataset[i][0])

  for i, acao in enumerate(dataset.columns[:-1]):
    dataset[acao] = dataset[acao] * pesos[i] * dinheiro_total

  dataset['soma valor'] = dataset.sum(axis = 1)

  datas = dataset['Date']
  dataset.drop(labels = ['Date'], axis = 1, inplace = True)
  dataset['taxa retorno'] = 0.0

  for i in range(1, len(dataset)):
    dataset['taxa retorno'][i] = np.log(dataset['soma valor'][i] /␣
↪dataset['soma valor'][i - 1]) * 100

  acoes_pesos = pd.DataFrame(data = {'Ações': colunas, 'Pesos': pesos})

  return dataset, datas, acoes_pesos, dataset.loc[len(dataset) - 1]['soma␣
↪valor']
```

[278]:
```
dataset, datas, acoes_pesos, soma_valor = alocacao_ativos(acoes_port, 10000, 10)
```

```
/tmp/ipykernel_22615/3471116991.py:20: FutureWarning:
```

```
Dropping of nuisance columns in DataFrame reductions (with 'numeric_only=None')
is deprecated; in a future version this will raise TypeError.  Select only valid
columns before calling the reduction.
```

[279]:
```
dataset
```

[279]:
```
            BITCOIN    CARDANO      LITECOIN       CHILIZ         USDC  \
0       2885.564869  77.634505   2370.522690  2801.328081  1864.949855
1       3022.440177  74.868094   2422.012383  2721.290136  1845.598217
2       2655.762149  74.627961   1875.500265  2617.240807  1872.793262
3       2783.597780  74.214558   1737.117199  2605.235115  1863.240746
4       2583.598441  72.666449   1838.076821  2576.821645  1849.105488
…               …          …             …            …           …
2809  409834.778060        NaN  90502.028680          NaN         NaN
2810  415434.760468        NaN  89913.788118          NaN         NaN
2811  413169.193815        NaN           NaN          NaN         NaN
2812  406935.672250        NaN           NaN          NaN         NaN
2813  397205.797905        NaN           NaN          NaN         NaN

          soma valor  taxa retorno
0      10000.000000      0.000000
1      10086.209007      0.858395
2       9095.924443    -10.334260
3       9063.405398     -0.358153
4       8920.268843     -1.591884
…               …             …
2809  500336.806740     -1.218201
2810  505348.548585      0.996690
2811  413169.193815    -20.139121
2812  406935.672250     -1.520206
2813  397205.797905     -2.420059

[2814 rows x 7 columns]
```

[280]:
```
acoes_pesos
```

[280]:
```
      Ações     Pesos
0   BITCOIN  0.288556
1   CARDANO  0.007763
2  LITECOIN  0.237052
3    CHILIZ  0.280133
4      USDC  0.186495
```

[281]:
```
datas
```

[281]:
```
0       2015-01-01
1       2015-01-02
2       2015-01-03
3       2015-01-04
4       2015-01-05
           ...
2809    2022-07-20
2810    2022-07-21
2811    2022-07-22
2812    2022-07-23
2813    2022-07-24
Name: Date, Length: 2814, dtype: object
```

[282]:
```
soma_valor
```

[282]:
```
397205.7979047329
```

[283]:
```
figura = px.line(x = datas, y = dataset['taxa retorno'], title = 'Retorno␣
 ↪diário do portfólio',
                 labels=dict(x="Data", y="Retorno %"))
figura.add_hline(y = dataset['taxa retorno'].mean(), line_color="red",␣
 ↪line_dash="dot", )
figura.show()
```

[284]:
```
figura = px.line(title = 'Evolução do patrimônio')
for i in dataset.drop(columns = ['soma valor', 'taxa retorno']).columns:
  figura.add_scatter(x = datas, y = dataset[i], name = i)
figura.show()
```

[285]:
```
figura = px.line(x = datas, y = dataset['soma valor'],
                 title = 'Evolução do patrimônio da Carteira',
                 labels=dict(x="Data", y="Valor R$"))
figura.add_hline(y = dataset['soma valor'].mean(),
                 line_color="green", line_dash="dot", )
figura.show()
```

Mais estatísticas sobre o portfólio aleatório

[286]:
```
# Retorno
dataset.loc[len(dataset) - 1]['soma valor'] / dataset.loc[0]['soma valor'] - 1
```

[286]:
```
38.720579790473295
```

[287]:
```
# Desvio-Padrão
dataset['taxa retorno'].std()
```

[287]:
```
4.712250446018992
```

[288]:
```
# Sharpe Ratio
(dataset['taxa retorno'].mean() / dataset['taxa retorno'].std())
```

[288]:
```
0.027766166684584117
```

[289]:
```
dinheiro_total = 10000
soma_valor - dinheiro_total
```

[289]:
```
387205.7979047329
```

0.3 Simulação da Fronteira Eficiente

[290]:
```
acoes_port
```

[290]:

	BITCOIN	CARDANO	LITECOIN	CHILIZ	USDC	Date
0	880.100050	12.89956	8.21562	0.07000	5.44500	2015-01-01
1	921.847150	12.43990	8.39407	0.06800	5.38850	2015-01-02
2	810.010000	12.40000	6.50000	0.06540	5.46790	2015-01-03
3	848.999990	12.33131	6.02040	0.06510	5.44001	2015-01-04
4	788.000000	12.07408	6.37030	0.06439	5.39874	2015-01-05
…	…	…	…	…	…	…
2809	125000.000000	NaN	313.65668	NaN	NaN	2022-07-20
2810	126708.000000	NaN	311.61799	NaN	NaN	2022-07-21
2811	126017.000000	NaN	NaN	NaN	NaN	2022-07-22
2812	124115.769950	NaN	NaN	NaN	NaN	2022-07-23
2813	121148.148952	NaN	NaN	NaN	NaN	2022-07-24

[2814 rows x 6 columns]

[291]:
```
log_ret = acoes_port.copy()
log_ret.drop(labels = ["Date"], axis = 1, inplace = True)
log_ret = np.log(log_ret/log_ret.shift(1))
log_ret
```

[291]:

	BITCOIN	CARDANO	LITECOIN	CHILIZ	USDC
0	NaN	NaN	NaN	NaN	NaN
1	0.046344	-0.036284	0.021488	-0.028988	-0.010431
2	-0.129333	-0.003213	-0.255723	-0.038985	0.014628
3	0.047013	-0.005555	-0.076648	-0.004598	-0.005114
4	-0.074561	-0.021081	0.056493	-0.010966	-0.007615
…	…	…	…	…	…
2809	-0.016387	NaN	0.007084	NaN	NaN
2810	0.013571	NaN	-0.006521	NaN	NaN
2811	-0.005468	NaN	NaN	NaN	NaN
2812	-0.015202	NaN	NaN	NaN	NaN
2813	-0.024201	NaN	NaN	NaN	NaN

```
[2814 rows x 5 columns]
```

[292]:
```
np.random.seed(42)
num_ports = 1000
all_weights = np.zeros((num_ports, len(acoes_port.columns[1:])))
ret_arr = np.zeros(num_ports)
vol_arr = np.zeros(num_ports)
sharpe_arr = np.zeros(num_ports)

for x in range(num_ports):
    # Weights
    weights = np.array(np.random.random(5))
    weights = weights/np.sum(weights)

    # Save weights
    all_weights[x,:] = weights

    # Expected return
    ret_arr[x] = np.sum((log_ret.mean() * weights))

    # Expected volatility
    vol_arr[x] = np.sqrt(np.dot(weights.T, np.dot(log_ret.cov(), weights)))

    # Sharpe Ratio
    sharpe_arr[x] = ret_arr[x]/vol_arr[x]
```

[293]:
```
print(f"Max Sharpe Ratio: {sharpe_arr.max()}")
print(f"Local do Max Sharpe Ratio: {sharpe_arr.argmax()}")
```

```
Max Sharpe Ratio: 0.06260877589164685
Local do Max Sharpe Ratio: 955
```

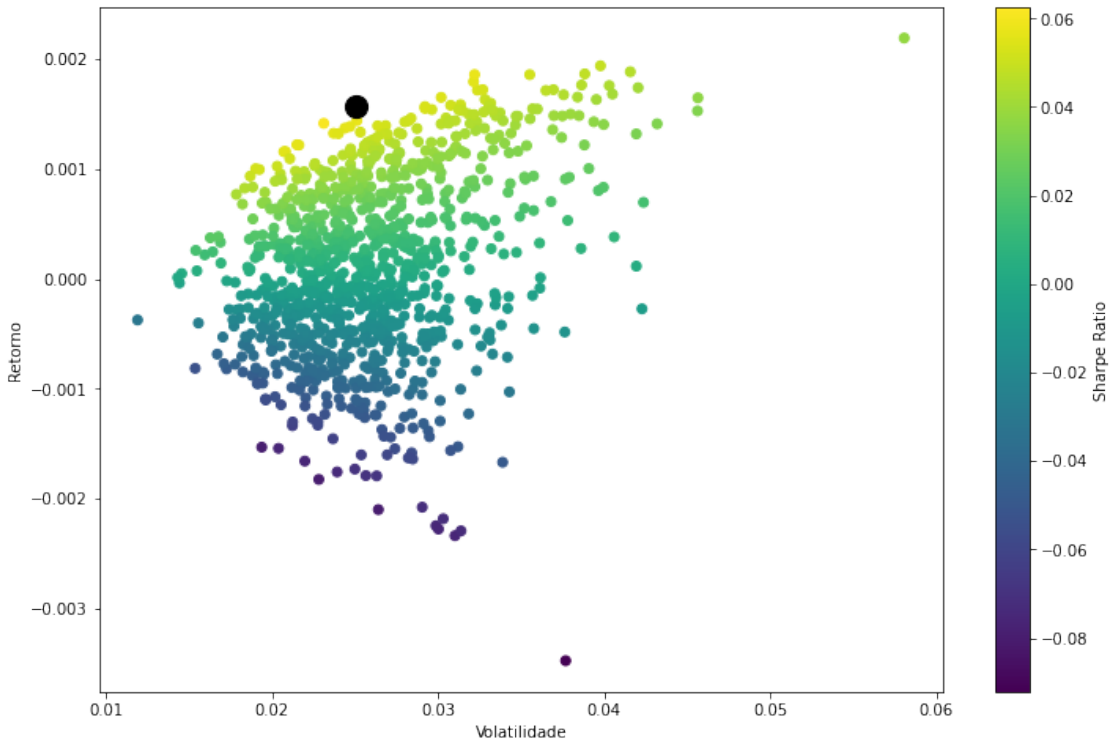
[294]:
```
# Pesos do Portfólio do Max Sharpe Ratio
print(all_weights[643,:])
```

```
[0.06771511 0.09521168 0.00114756 0.41402801 0.42189764]
```

[295]:
```
# salvando os dados do Max Sharpe Ratio
max_sr_ret = ret_arr[sharpe_arr.argmax()]
max_sr_vol = vol_arr[sharpe_arr.argmax()]
print(max_sr_ret)
print(max_sr_vol)
```

```
0.0015667370679111631
0.025024240541335906
```

[296]:
```
plt.figure(figsize=(12,8))
plt.scatter(vol_arr, ret_arr, c=sharpe_arr, cmap='viridis')
plt.colorbar(label='Sharpe Ratio')
plt.xlabel('Volatilidade')
plt.ylabel('Retorno')
plt.scatter(max_sr_vol, max_sr_ret,c='black', s=200) # black dot
plt.show()
```



Nós podemos ver no gráfico assima o conjunto de portfólios simulados, pois o peso w_i de cada ativo foi simulado e criamos um conjunto de $n = 1000$ carteiras e escolhemos no ponto vermelho a que tem maior **Sharpe Ratio**, que é a razão retorno sobre a volatilidade. Esse dado nos da uma noção do portfólio ponderado pelo risco.

[297]:
```
def get_ret_vol_sr(weights):
    weights = np.array(weights)
    ret = np.sum(log_ret.mean() * weights)
    vol = np.sqrt(np.dot(weights.T, np.dot(log_ret.cov(), weights)))
    sr = ret/vol
    return np.array([ret, vol, sr])

def neg_sharpe(weights):
# the number 2 is the sharpe ratio index from the get_ret_vol_sr
    return get_ret_vol_sr(weights)[2] * -1
```

```
def check_sum(weights):
    #return 0 if sum of the weights is 1
    return np.sum(weights)-1
```

[298]:
```
cons = ({'type': 'eq', 'fun': check_sum})
bounds = ((0,1), (0,1), (0,1), (0,1), (0,1))
init_guess = ((0.2),(0.2),(0.2),(0.2),(0.2))
```

[299]:
```
op_results = optimize.minimize(neg_sharpe, init_guess, method="SLSQP", bounds=␣
 ↪bounds, constraints=cons)
print(op_results)
```

```
     fun: -0.06323003792313457
     jac: array([-9.77870077e-05,  1.72606335e-01, -5.08139841e-04,
7.20449723e-04,
       -1.30431727e-05])
 message: 'Optimization terminated successfully'
    nfev: 79
     nit: 13
    njev: 13
  status: 0
 success: True
       x: array([0.60432927, 0.        , 0.17477836, 0.20332145, 0.01757092])
```

[300]:
```
frontier_y = np.linspace(-0.0006, 0.0008, 200)
```

[301]:
```
def minimize_volatility(weights):
    return get_ret_vol_sr(weights)[1]
```

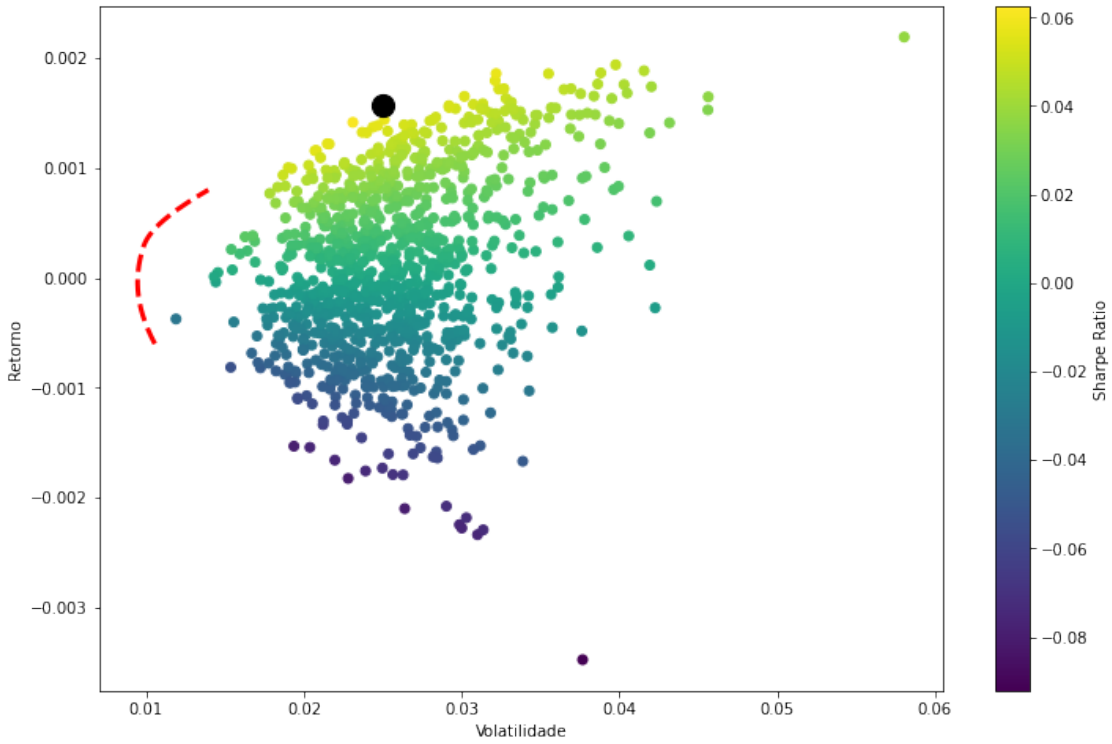
[302]:
```
frontier_x = []

for possible_return in frontier_y:
    cons = ({'type':'eq', 'fun':check_sum},
            {'type':'eq', 'fun': lambda w: get_ret_vol_sr(w)[0] -␣
 ↪possible_return})

    result = optimize.minimize(minimize_volatility,init_guess,method='SLSQP',␣
 ↪bounds=bounds, constraints=cons)
    frontier_x.append(result['fun'])
```

[303]:
```
plt.figure(figsize=(12,8))
plt.scatter(vol_arr, ret_arr, c=sharpe_arr, cmap='viridis')
plt.colorbar(label='Sharpe Ratio')
plt.xlabel('Volatilidade')
plt.ylabel('Retorno')
plt.plot(frontier_x,frontier_y, 'r--', linewidth=3)
```

```
plt.scatter(max_sr_vol, max_sr_ret,c='black', s=200)
# plt.savefig('cover.png')
plt.show()
```



[ ]: