```
import requests
import warnings
import math

import pandas as pd
import datetime as dt

import plotly.express as px

from tqdm import tqdm
from gql import gql, Client # to use GraphQL
from gql.transport.requests import RequestsHTTPTransport
import matplotlib.pyplot as plt
import numpy as np
from datetime import datetime, timedelta

%matplotlib inline

warnings.filterwarnings('ignore')
```

Uniswap V3 position with hedge

The document contains calculations for the liquidity, tokens amounts and fees. The formulae may be found in the paper paper by Atis Elsts and in the original whitepaper for Uniswap V3.

Load Uniswap V3 pool data using TheGraph

```
# connect to the Uniswap V3 Subgraph
uni_transport = RequestsHTTPTransport(
    url = 'https://api.thegraph.com/subgraphs/name/uniswap/uniswap-
v3', #here we can use uniswap-v3
    verify = True,
    retries=3,
)
client = Client(transport = uni_transport)

data_pools = []

# get the set of pools available in the Uniswap V3 Subgraph
# the examples for Uniswap are available in the Uniswap documentation:
https://docs.uniswap.org/api/subgraph/guides/examples
# GraphQL tutorials: https://thegraph.com/docs/en/querying/querying-
best-practices/

query = gql(
    """
query ($first: Int!, $skip: Int!) {
  pools (first: $first, skip: $skip){
```

```
    id
    volumeUSD
    token0{
        name
    }
    token1{
        name
    }
  }
}
"""
)

page_size = 1000
skip = 0

while True:
    if skip > 5000:
        break
    vars = {"first": page_size, "skip": skip}
    result = client.execute(query, variable_values=vars)

    data = []
    for i in result['pools']:
        data.append([
            i['id'],
            i['volumeUSD'],
            i['token0']['name'],
            i['token1']['name']
        ])

    df = pd.DataFrame(data)
    df.columns = ['id','volumeUSD','name0','name1']
    df['Pair'] = df['name0'] + '-' + df['name1']
    df['volumeUSD'] = pd.to_numeric(df['volumeUSD'])

    data_pools.extend(df.to_dict('records'))
    skip += page_size

    if not result['pools']:
        break


data_pools = pd.DataFrame(data_pools)

# select the largest pools with at least $1B in trading volume

data_pools = data_pools.reset_index()
data_pools['volumeUSD'] = data_pools['volumeUSD'].astype('int64')
large_pools = data_pools[ data_pools['volumeUSD'] > 1_000_000_000]
```

Liquidity provision in Uniswap V3

USDC - WETH pool: 0x11b815efb8f581194ae79006d24e0d814b7697f6

0x11b815efB8f581194ae79006d24E0d814B7697F6

```
data_pool = []

# query for the USDC-WETH pool
query = gql(
    """
    {
        poolDayDatas(
            first: 1000
            orderDirection: desc
            where: {pool: 
"0x11b815efb8f581194ae79006d24e0d814b7697f6"}
        ) {
            date
            token0Price
            token1Price
            feesUSD
            liquidity
            volumeUSD
        }
    }
    """
)


result = client.execute(query, variable_values=vars)

data = []
for i in result['poolDayDatas']:
    data.append([
        i['date'],
        i['token0Price'],
        i['token1Price'],
        i['feesUSD'],
        i['liquidity'],
        i['volumeUSD']
    ])


df = pd.DataFrame(data)
df.columns = ['date', 'token1Price','token0Price', 'feesUSD', 
'liquidity', 'volumeUSD']

df['token0Price'] = pd.to_numeric(df['token0Price'])
df['token1Price'] = pd.to_numeric(df['token1Price'])
```

```
df['feesUSD'] = pd.to_numeric(df['feesUSD'])
df['USDC/WETH'] = pd.to_numeric(df['token0Price']/df['token1Price'])
df['datetime'] = pd.to_datetime(df['date']*1000000000)
df['liquidity'] =  df['liquidity'].astype(float)
df['volumeUSD'] = pd.to_numeric(df['volumeUSD'])

# df

data_pool = df.copy()

data_pool['datetime'] = data_pool['datetime'].dt.date
data_pool = data_pool[['token0Price', 'token1Price', 'feesUSD',
'liquidity', 'datetime', 'volumeUSD']]
# data_pool
```

To construct the pseudo delta neutral strategy we need to use perps. We'll take the data on ETH perps from the Binance API

```
# funding rates for ETH

url = 'https://fapi.binance.com/fapi/v1/fundingRate'
symbol = 'ETHUSDT'

start_time = dt.datetime(2021, 5, 5).timestamp() * 1000
end_time = dt.datetime(2023, 10, 26).timestamp() * 1000

data = requests.get(url, params={'symbol': symbol, 'startTime':
int(start_time)}).json()
last_time = data[-1]['fundingTime']


while last_time <= end_time:
    data.extend(requests.get(url, params={'symbol': symbol,
'startTime': int(last_time)}).json())
    last_time = data[-1]['fundingTime']

df = pd.DataFrame(data)
df['datetime'] = pd.to_datetime(df['fundingTime'], unit='ms')
df['fundingRate'] = pd.to_numeric(df['fundingRate'])
df = df.drop_duplicates()

data_funding = df.copy()

data_funding['datetime'] = data_funding['datetime'].dt.date
data_funding = data_funding.groupby('datetime').sum()
data_funding = data_funding.reset_index()
data_funding = data_funding[['datetime', 'fundingRate']]

all_data = pd.merge(data_pool, data_funding, how="left",
on='datetime')
all_data['volume24H'] = all_data['volumeUSD'].rolling(window=7).mean()
```

```
for i in range(8):
    all_data['volume24H'][i] = data_pool['volumeUSD'][i]
# all_data
#print(data_pool)

window_size = 30  # Размер окна для вычисления среднего
all_data['volatility'] =
all_data['token0Price'].rolling(window=window_size).std()
for i in range(window_size-1):
    all_data['volatility'][i] = all_data['volatility'][window_size-1]
#all_data['volatility'] = all_data["token0Price"].std()
# print(all_data)
# print(all_data['volatility'][6])

# px.line(all_data, x='datetime', y='liquidity')


#abs(self._states[self._states['datetime'] <= timestamp]
['token0Price'].pct_change().std()
```

Startegy Backtest

Liquidity provision strategy: put capital into the Uniswap V3 pool and use perps to hedge the position.

```
class UniswapV3Position:

    def __init__(self, token0_amount: float, token1_amount: float,
liquidity: float,
                 price_current: float, price_upper: float,
price_lower: float):
        self._token0_amount: float = token0_amount
        self._token1_amount: float = token1_amount
        self._liquidity: float = liquidity
        self._price_current: float = price_current
        self._price_init: float = price_current
        self._price_upper: float = price_upper
        self._price_lower: float = price_lower
        self._acc_fees: float = 0

    def update_state(self, price: float) -> None:
        if price < self._price_lower:
            self._token0_amount = 0
            self._token1_amount = self._liquidity *
(1/(self._price_lower**0.5) - 1/(self._price_upper**0.5))
        elif self._price_lower <= price < self._price_upper:
            self._token0_amount = self._liquidity * (price**0.5 -
self._price_lower**0.5)
```

```
            self._token1_amount = self._liquidity * (1/(price**0.5) -
1/(self._price_upper**0.5))
        else:
            self._token0_amount = self._liquidity *
(self._price_upper**0.5 - self._price_lower**0.5)
            self._token1_amount = 0
        self._price_current = price

    def balance(self, side: bool = True) -> float:
        if side:
            return self._token0_amount + self._token1_amount *
self._price_current + self._acc_fees
        return self._token0_amount / self._price_current +
self._token1_amount + self._acc_fees / self._price_current

    @classmethod
    def price_to_tick(cls, price: float) -> float:
        return math.floor(math.log(price, 1.0001))

    @classmethod
    def tick_to_price(clas, tick: float) -> float:
        return 1.0001 ** tick

    def __str__(self) -> str:
        return f"token0: {self._token0_amount}, token1:
{self._token1_amount}, liquidity: {self._liquidity}, price_current:
{self._price_current}, price_upper: {self._price_upper}, price_lower:
{self._price_lower}"

    def __repr__(self) -> str:
        return self.__str__()


def create_position_by_notional(
            deposit_amount_in_notional: float,
            price_current: float, price_upper: float, price_lower:
float,
    ) -> UniswapV3Position:
        X = deposit_amount_in_notional

        liquidity = (X/2/price_current) / (1/(price_current**0.5) -
1/(price_upper**0.5))
        token0_amount = liquidity * (price_current**0.5 -
price_lower**0.5)

        ratio = token0_amount / (X/2/price_current)
        new_deposit_amount = X/(ratio + price_current)

        token1_amount = new_deposit_amount
        liquidity = new_deposit_amount /  (1/(price_current**0.5) -
```

```
1/(price_upper**0.5))
        token0_amount = liquidity * (price_current**0.5 -
price_lower**0.5)

        return UniswapV3Position(token0_amount, token1_amount,
liquidity, price_current, price_upper, price_lower)

class HedgePosition:
    def __init__(self, size: float, entry_price: float):
        self._size: float = size
        self._entry_price: float = entry_price
        self._current_price: float = entry_price

    def update_state(self, price: float) -> None:
        self._current_price = price

    def pnl(self) -> float:
        return self._size * (self._current_price - self._entry_price)

    def __str__(self) -> str:
        return f'BaseHedgePosition(size={self._size},
entry_price={self._entry_price}, current_price={self._current_price})'



class Hedge:
    def __init__(self):
        self._position: HedgePosition = None
        self._balance: float = 0
        self._current_price: float = None
        self._trading_fee: float = 0.0003 # 0.03% комиссия взята с
официального сайта

    def deposit(self, amount: float):
        if amount <= 0:
            raise Exception(f'Cannot deposit non-positive amount
{amount}')
        self._balance += amount

    def withdraw(self, amount: float):
        if amount > self._balance:
            raise Exception(f'Not enough balance to withdraw {amount},
available {self._balance}')
        self._balance -= amount

    @property
    def balance(self) -> float:
        return self._balance

    @property
```

```
    def position(self) -> HedgePosition:
        return self._position

    def margin_balance(self) -> float:
        if not self._position:
            return self._balance
        return self._balance + self._position.pnl()

    def update_state(self, price: float, funding: float) -> None:
        self._current_price = price
        if self._position:
            self._position.update_state(price)
            self._balance += funding * abs(self._position._size) *
self._current_price
        self.__check_liquidation()

    def open_position(self, size: float, entry_price: float) -> None:
        if self._position:
            raise Exception(f'Cannot open position, already have one
{self._position}')

        if size > 0:
            raise Exception(f'Cannot open short position {size}')

        self._position = HedgePosition(size, entry_price)
        self._balance -= abs(size) * entry_price * self._trading_fee

    def close_position(self) -> None:
        if not self._position:
            return
        self._balance -= abs(self._position._size) *
self._current_price * self._trading_fee
        self._balance += self._position.pnl()
        self._position = None

    def __check_liquidation(self):
        if self._position:
            # liquidate if margin balance is 5% of the position size
            if self.margin_balance() < abs(self._position._size) *
0.05:
                self._balance = 0
                self._position = None
```

Ниже можно увидеть, как выглядила изначальная стратегия на нашем семинаре: у нас есть пул и хедж, задается некоторый начальный рендж для пула и затем ребалансировки происходили только в момент, когда цена выходит за пределы ренджа. В качестве пула я взял второй по объему из всех существующих сейчас пулов, выбрал его, так как в отличии от самого первого пула скорее всего во втором будем меньше алгоритмической торговли, поэтому эффект "рыночного эмпакта", скорее всего будет не таким сильным, а значит смоделированные на бумаге стратегии будут релевантнее на реальном рынке, а значит их результаты интереснее для изучения. Пояснения: в самом большом пуле много алгоритмической торговли в силу высокой ликвидности (в обычном смысле), а во-втором поменьше, а значит вероятность, что будет существовать бот, который будет "кушать" нашу стратегию намного ниже, однако преймущества большого объемного пула сохраняются.

Я буду брать ее за основу и последовательно изменять сомнительные куски, так, я планирую добавить\изменить:

- Δ - хеджирование. Дело в том, что в нашей изначальной стратегии бралась некоторая фиксированная H, что мне очевидно нерелевантно в условиях рынка с меняющимися волатильностями, трендами и т.п. -При невалидных значениях в подкоренном выражении попытаться подобрать значение H. В формуле есть используются функции, которую уменьшают ОДЗ, поэтому могут появлять невалидные значения, не позволяющие оценить H, значит требуется в таких случаях как-то выбирать H

- Ребалансировка хеджирования чаще, чем раз в изменение рэнжа. Очевидно, если очень это не делать, то при росте рынка наше хеджирование превращается в шорт, что очень сильно бьёт по нашим накоплениям.

- Изменение оценки стандартного отклонения. В изначальном коде уж очень странно она сделана и в первых и последних числах наших исторических данных может давать нерелевантные значения.

Хочу заметить, что затем все эти позиции я буду оптимизировать через перебор всех вариантов, таким образом чтобы "изначальный вариант" также учитывался, поэтому можно будет увидеть оптимизацию. енияниняне}

```
class Strategy:
    def __init__(self,
                 states: pd.DataFrame,STD_COUNT,STD_TIMERANGE
                ):
        self.params: dict = {
            'STD_COUNT': STD_COUNT,
            'START_EQUITY': 100_000,
            'STD_TIMERANGE': STD_TIMERANGE, # days
        }
        self._hedge: Hedge = Hedge()
        self._pool_position: UniswapV3Position = None
        self._states: pd.DataFrame = states
        self._data = []

    def update_fee(self, price: float, i: dict):
    #10**(-18)*math.ceil(10**18 *
        FeesTees = 0.0005
```

```
        liquidityAmount1 = self._pool_position._token1_amount *
(self._pool_position._price_upper**(0.5) *
self._pool_position._price_lower**(0.5)) /
(self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))
        liquidityAmount0 = self._pool_position._token0_amount /
(self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))

        if price < self._pool_position._price_lower:
            deltaL = liquidityAmount0
        elif (self._pool_position._price_lower <= price) and (price <
self._pool_position._price_upper):
            deltaL = min(liquidityAmount0, liquidityAmount1)
        else:
            deltaL = liquidityAmount1
        self._pool_position._acc_fees += FeesTees *
self._states['volume24H'][i] * (deltaL/ (self._states['liquidity']
[i]*10**(-12) + deltaL))


    def calculate_std(self, timestamp: dt.datetime) -> float:
        return abs(self._states[self._states['datetime'] <= timestamp]
['token0Price'].pct_change().std())

    def run(self):
        remember_price = None
        df_for_run = pd.DataFrame(self._states)
        for i, state in df_for_run.iterrows():
            if i < self.params['STD_TIMERANGE']:
            #print(f'Strategy | Skipping {state["datetime"]}')
                continue

            if not remember_price:
                remember_price = float(state['token0Price'])


            self._hedge.update_state(state['token0Price'],
state['fundingRate'])
            if self._pool_position:
                self._pool_position.update_state(state['token0Price'])
                self.update_fee(self._pool_position._price_current, i)
                if (self._pool_position._token0_amount *
self._pool_position._token1_amount == 0):
                    self.rebalance(state)
                    remember_price = None
            else:
                 self.rebalance(state)

            self._data.append([
```

```
                state['datetime'],
                state['token0Price'],
                self._pool_position.balance(),
                self._hedge.margin_balance(),
                self._pool_position.balance() +
self._hedge.margin_balance(),
                self._pool_position._price_upper,
                self._pool_position._price_lower,
            ])

        return pd.DataFrame(self._data, columns=['datetime', 'price',
'pool_balance', 'hedge_balance', 'total_balance', 'price_upper',
'price_lower'])

    def rebalance(self, state):

    #print(f'Strategy | Start rebalancing at {state["datetime"]}')

        std = self.calculate_std(state['datetime'])
        #print(f'Strategy | Calculated std {std}')

        if self._pool_position is not None:
            pool_balance: float = self._pool_position.balance() * (1 -
0.0005) # some fees and slippage
            self._hedge.close_position()
            equity: float = pool_balance +
self._hedge.margin_balance()
        else:
            equity: float = self.params['START_EQUITY']

        H=1/3



        # virtual witfhdraw and deposit for rebalancing capital
        self._hedge.withdraw(self._hedge.margin_balance())
        self._hedge.deposit(H * equity)

        self._pool_position = create_position_by_notional(
            (1-H)*equity,
            price_current=state['token0Price'],
            price_upper=state['token0Price'] * (1 + std *
self.params['STD_COUNT']),
            price_lower=state['token0Price'] * (1 - std *
self.params['STD_COUNT']),
        )

        self._hedge.open_position(
            size=-(self._pool_position.balance() / 2) /
state['token0Price'],
```

```
            entry_price=state['token0Price'],
        )
        # print(f'Strategy | Created pool position
{self._pool_position}')
        # print(f'Strategy | New balances: pool
{self._pool_position.balance()}, hedge {self._hedge.margin_balance()},
equity {self._pool_position.balance() +
self._hedge.margin_balance()}')
        # print(f'Strategy | End rebalancing at {state["datetime"]}')



# you can take filtered data
# filtered_data = all_data[all_data['datetime'] > dt.datetime(2021, 5,
5).date()]
strategy = Strategy(all_data.sort_values('datetime').reset_index(), 5,
30)
data = strategy.run()


df = pd.DataFrame(data)


# scale all balances to first day
df['pool_balance'] = df['pool_balance'] / df['pool_balance'][0]
df['hedge_balance'] = df['hedge_balance'] / df['hedge_balance'][0]
df['total_balance'] = df['total_balance'] / df['total_balance'][0]
print("Income:",df['total_balance'].to_list()[-1])

px.line(df.sort_values('datetime'), x='datetime', y=['pool_balance',
'hedge_balance', 'total_balance'])

Income: 0.7325080422688711
```

Первое, что я предлагаю это поменять хедж, так как ребалансировка у нас происходит только при выходе за границы хэджа, то в какой-то момент мы начинаем терять деньги из-за этого и следует делать ребалансировку раз в какой-то промежуток, в качестве "промежутка" будем брать колебания цены, так, если цена вышла за некоторый промежуток, то мы делаем ребаланс, я рассматриваю самую банальную модель, когда мы

просто оцениваем
$state['token0Price']*(1-koef)<¿remember_{price}<¿(1+koef)*state['token0Price']$
, однако также можно прикрутить волатильность и как-то менять этот промежуток.

Проведём бектесты

```
class Strategy:
            def __init__(self,
                         states: pd.DataFrame,STD_COUNT,STD_TIMERANGE
                        ):
                self.params: dict = {
                    'STD_COUNT': STD_COUNT,
                    'START_EQUITY': 100_000,
                    'STD_TIMERANGE': STD_TIMERANGE, # days
                }
                self._hedge: Hedge = Hedge()
                self._pool_position: UniswapV3Position = None
                self._states: pd.DataFrame = states
                self._data = []

            def update_fee(self, price: float, i: dict):
            #10**(-18)*math.ceil(10**18 *
                FeesTees = 0.0005
                liquidityAmount1 = self._pool_position._token1_amount
* (self._pool_position._price_upper**(0.5) *
self._pool_position._price_lower**(0.5)) /
(self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))
                liquidityAmount0 = self._pool_position._token0_amount
/ (self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))

                if price < self._pool_position._price_lower:
                    deltaL = liquidityAmount0
                elif (self._pool_position._price_lower <= price) and
(price < self._pool_position._price_upper):
                    deltaL = min(liquidityAmount0, liquidityAmount1)
                else:
                    deltaL = liquidityAmount1
                self._pool_position._acc_fees += FeesTees *
self._states['volume24H'][i] * (deltaL/ (self._states['liquidity']
[i]*10**(-12) + deltaL))


            def calculate_std(self, timestamp: dt.datetime) -> float:
                return abs(self._states[self._states['datetime'] <=
timestamp]['token0Price'].pct_change().std())

            def run(self):
                remember_price = None
```

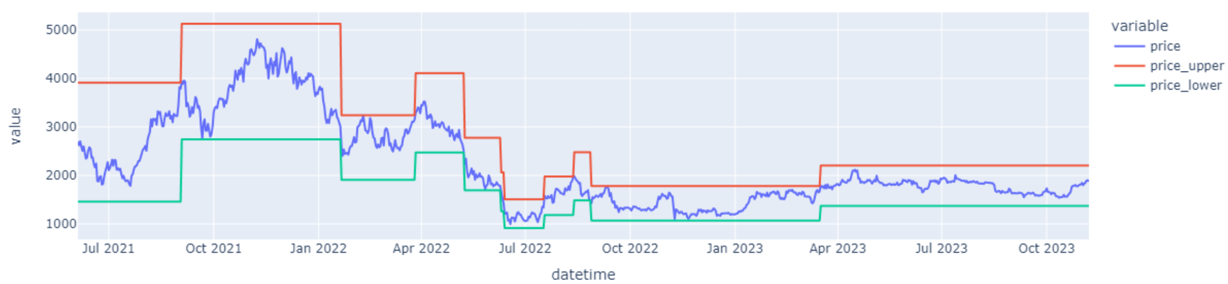
```
                df_for_run = pd.DataFrame(self._states)
                for i, state in df_for_run.iterrows():
                    if i < self.params['STD_TIMERANGE']:
                    #print(f'Strategy | Skipping {state["datetime"]}')
                        continue

                    if not remember_price:
                        remember_price = float(state['token0Price'])


                    self._hedge.update_state(state['token0Price'],
state['fundingRate'])
                    if self._pool_position:

self._pool_position.update_state(state['token0Price'])

self.update_fee(self._pool_position._price_current, i)
                        if (self._pool_position._token0_amount *
self._pool_position._token1_amount == 0):
                            self.rebalance(state,True)
                            remember_price = None
                        if not remember_price:
                            remember_price =
float(state['token0Price'])
                        if not (state['token0Price']*(1-koef)<=
remember_price <= (1+koef) * state['token0Price']):
                            self.rebalance(state, False)
                            remember_price = None
                    else:
                        self.rebalance(state, True)

                    self._data.append([
                        state['datetime'],
                        state['token0Price'],
                        self._pool_position.balance(),
                        self._hedge.margin_balance(),
                        self._pool_position.balance() +
self._hedge.margin_balance(),
                        self._pool_position._price_upper,
                        self._pool_position._price_lower,
                    ])

                return pd.DataFrame(self._data, columns=['datetime',
'price', 'pool_balance', 'hedge_balance', 'total_balance',
'price_upper', 'price_lower'])

            def rebalance(self, state, bool):

            #print(f'Strategy | Start rebalancing at
```

```
{state["datetime"]}')

                std = self.calculate_std(state['datetime'])
            #print(f'Strategy | Calculated std {std}')

                if self._pool_position is not None:
                    pool_balance: float =
self._pool_position.balance() * (1 - 0.0005) # some fees and slippage
                    self._hedge.close_position()
                    equity: float = pool_balance +
self._hedge.margin_balance()
                else:
                    equity: float = self.params['START_EQUITY']

                def is_valid_number(number):
            # Проверка на не NaN
                    if np.isnan(number):
                        return False
                # Проверка на не равно 0 и больше нуля
                    if number > 0:
                        return True
                    return False

            #print("decim:",state['token0Price'] * (1 - std *
self.params['STD_COUNT']))


                # if(is_valid_number(state['token0Price'] * (1 - std *
self.params['STD_COUNT']))):
                #     r = math.sqrt((state['token0Price'] * (1 + std *
self.params['STD_COUNT']))/(state['token0Price'] * (1 - std *
self.params['STD_COUNT'])))
                #     H = (math.sqrt(r) - 1)/(r-1)
                # else: H = 0.00001
                H =1/3


            # virtual witfhdraw and deposit for rebalancing capital
                self._hedge.withdraw(self._hedge.margin_balance())
                self._hedge.deposit(H * equity)

                if(bool):
                    self._pool_position = create_position_by_notional(
                        (1-H)*equity,
                        price_current=state['token0Price'],
                        price_upper=state['token0Price'] * (1 + std *
self.params['STD_COUNT']),
                        price_lower=state['token0Price'] * (1 - std *
self.params['STD_COUNT']),
```

```
                    )
                else:
                    self._pool_position = create_position_by_notional(
                        (1-H)*equity,
                        price_current=state['token0Price'],
                        price_upper =
self._pool_position._price_upper,
                        price_lower = self._pool_position._price_lower
                    )


                self._hedge.open_position(
                    size=-(self._pool_position.balance() / 2) /
state['token0Price'],
                    entry_price=state['token0Price'],
                )
            # print(f'Strategy | Created pool position
{self._pool_position}')
            # print(f'Strategy | New balances: pool
{self._pool_position.balance()}, hedge {self._hedge.margin_balance()},
equity {self._pool_position.balance() +
self._hedge.margin_balance()}')
            # print(f'Strategy | End rebalancing at
{state["datetime"]}')




        # you can take filtered data
        # filtered_data = all_data[all_data['datetime'] >
dt.datetime(2021, 5, 5).date()]
koef = 0.4 #заметим, что на значениях 1 выгода больше
print("koef:",koef)
strategy = Strategy(all_data.sort_values('datetime').reset_index(), 5,
30)
data = strategy.run()


df = pd.DataFrame(data)


        # scale all balances to first day
df['pool_balance'] = df['pool_balance'] / df['pool_balance'][0]
df['hedge_balance'] = df['hedge_balance'] / df['hedge_balance'][0]
df['total_balance'] = df['total_balance'] / df['total_balance'][0]
print("Income:", df['total_balance'].to_list()[-1])

px.line(df.sort_values('datetime'), x='datetime', y=['pool_balance',
'hedge_balance', 'total_balance'])
```

```
koef: 0.4
Income: 0.7281448727658772
```


```
px.line(df, x='datetime', y=['price', 'price_upper', 'price_lower'])
```




```
koef = 1
print("koef",koef)
strategy = Strategy(all_data.sort_values('datetime').reset_index(), 5,
30)
data = strategy.run()


df = pd.DataFrame(data)


        # scale all balances to first day
df['pool_balance'] = df['pool_balance'] / df['pool_balance'][0]
df['hedge_balance'] = df['hedge_balance'] / df['hedge_balance'][0]
df['total_balance'] = df['total_balance'] / df['total_balance'][0]
print("Income:", df['total_balance'].to_list()[-1])

px.line(df.sort_values('datetime'), x='datetime', y=['pool_balance',
'hedge_balance', 'total_balance'])
```

```
koef 1
Income: 0.7325080422688711
```

Казалось бы, значения уменьшились, но как показываю бектесты на других значения на самом деле стратегия достаточно хорошо работает.

Вообще, на самом деле, если взять koef = 1, то по сути мы как бы "уберём" эту стратегию, а значит если мы будем проделывать бектесты, то хуже точно не станет.

Давайте воспользумся Δ хэджированием, для этого при каждой ребалансеровке будем высчитывать некоторый коэффициент H, который будет показывать долю, которую мы хеджируем. Согласно этой статье формулы для рассчета будут следующие: $r=\sqrt{\frac{\text{PriceUpper}}{\text{PriceLower}}}$, $H=\frac{\sqrt{r}-1}{r-1}$

Хочу заметить, что на невалидных данных я беру некоторую заданную H, которую потом мы будем оптимизировать через тесты

```
class Strategy:
    def __init__(self,
                 states: pd.DataFrame,STD_COUNT,STD_TIMERANGE,
START_EQUITY, H, bool
                ):
        self.params: dict = {
            'STD_COUNT': STD_COUNT,
            ''
            'START_EQUITY': START_EQUITY,
            'STD_TIMERANGE': STD_TIMERANGE,
            'H': H,
            'Bool': bool,# days
        }
        self._hedge: Hedge = Hedge()
        self._pool_position: UniswapV3Position = None
        self._states: pd.DataFrame = states
        self._data = []
```

```
    def update_fee(self, price: float, i: dict):
        #10**(-18)*math.ceil(10**18 *
        FeesTees = 0.0005
        liquidityAmount1 = self._pool_position._token1_amount *
(self._pool_position._price_upper**(0.5) *
self._pool_position._price_lower**(0.5)) /
(self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))
        liquidityAmount0 = self._pool_position._token0_amount /
(self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))

        if price < self._pool_position._price_lower:
            deltaL = liquidityAmount0
        elif (self._pool_position._price_lower <= price) and (price <
self._pool_position._price_upper):
            deltaL = min(liquidityAmount0, liquidityAmount1)
        else:
            deltaL = liquidityAmount1
        self._pool_position._acc_fees += FeesTees *
self._states['volume24H'][i] * (deltaL/ (self._states['liquidity']
[i]*10**(-12) + deltaL))


    def calculate_std(self, timestamp: dt.datetime) -> float:
        return abs(self._states[self._states['datetime'] <= timestamp]
['token0Price'].pct_change().std())

    def run(self):
        df_for_run = pd.DataFrame(self._states)
        for i, state in df_for_run.iterrows():
            if i < self.params['STD_TIMERANGE']:
                #print(f'Strategy | Skipping {state["datetime"]}')
                continue
            self._hedge.update_state(state['token0Price'],
state['fundingRate'])
            if self._pool_position:
                self._pool_position.update_state(state['token0Price'])
                self.update_fee(self._pool_position._price_current, i)
                if (self._pool_position._token0_amount *
self._pool_position._token1_amount == 0):
                    self.rebalance(state)
            else:
                self.rebalance(state)

            self._data.append([
                state['datetime'],
                state['token0Price'],
                self._pool_position.balance(),
                self._hedge.margin_balance(),
```

```
                self._pool_position.balance() +
self._hedge.margin_balance(),
                self._pool_position._price_upper,
                self._pool_position._price_lower,
            ])

        return pd.DataFrame(self._data, columns=['datetime', 'price',
'pool_balance', 'hedge_balance', 'total_balance', 'price_upper',
'price_lower'])

    def rebalance(self, state):

        #print(f'Strategy | Start rebalancing at {state["datetime"]}')

        std = self.calculate_std(state['datetime'])

        if self._pool_position is not None:
            pool_balance: float = self._pool_position.balance() * (1 -
0.0005) # some fees and slippage
            self._hedge.close_position()
            equity: float = pool_balance +
self._hedge.margin_balance()
        else:
            equity: float = self.params['START_EQUITY']

        def is_valid_number(number):
            # Проверка на не NaN
            if np.isnan(number):
                return False
            # Проверка на не равно 0 и больше нуля
            if number > 0:
                return True
            return False

        #print("decim:",state['token0Price'] * (1 - std *
self.params['STD_COUNT']))

        if(self.params['Bool']):
            if(is_valid_number(state['token0Price'] * (1 - std *
self.params['STD_COUNT']))):
                r = math.sqrt((state['token0Price'] * (1 + std *
self.params['STD_COUNT']))/(state['token0Price'] * (1 - std *
self.params['STD_COUNT'])))
                H = (math.sqrt(r) - 1)/(r-1)
            else: H = self.params['H']
        else:
            H = self.params['H']

        # virtual witfhdraw and deposit for rebalancing capital
        self._hedge.withdraw(self._hedge.margin_balance())
```

```
        self._hedge.deposit(H * equity)

        self._pool_position = create_position_by_notional(
            (1-H)*equity,
            price_current=state['token0Price'],
            price_upper=state['token0Price'] * (1 + std *
self.params['STD_COUNT']),
            price_lower=state['token0Price'] * (1 - std *
self.params['STD_COUNT']),
        )
        self._hedge.open_position(
            size=-(self._pool_position.balance() / 2) /
state['token0Price'],
            entry_price=state['token0Price'],
        )



# you can take filtered data
# filtered_data = all_data[all_data['datetime'] > dt.datetime(2021, 5,
5).date()]
strategy = Strategy(all_data.sort_values('datetime').reset_index(), 5,
30, 1000000, 0.0001,True) #тут будет такая запись
Strategy(all_data.sort_values('datetime').reset_index(), 3, 30, S,
H,True)
data = strategy.run()


df = pd.DataFrame(data)


# scale all balances to first day
df['pool_balance'] = df['pool_balance'] / df['pool_balance'][0]
df['hedge_balance'] = df['hedge_balance'] / df['hedge_balance'][0]
df['total_balance'] = df['total_balance'] / df['total_balance'][0]
print("Income:",df['total_balance'].to_list()[-1])

px.line(df.sort_values('datetime'), x='datetime', y=['pool_balance',
'hedge_balance', 'total_balance'])
```

```
Income: 0.7747093822700238
```

Результаты выросли в примерно на 5% процентов, поэтому будем придерживаться модели Δ-хеджирования

```
from datetime import datetime, timedelta
class Strategy:
    def __init__(self,
                 states: pd.DataFrame,STD_COUNT,STD_TIMERANGE,
START_EQUITY, koef, H, bool,day
                ):
        self.params: dict = {
            'STD_COUNT': STD_COUNT,
            ''
            'START_EQUITY': START_EQUITY,
            'STD_TIMERANGE': STD_TIMERANGE,
            'H': H,
            'Bool': bool,# days
            "Koef":koef,
            "Day":day
        }
        self._hedge: Hedge = Hedge()
        self._pool_position: UniswapV3Position = None
        self._states: pd.DataFrame = states
        self._data = []

    def update_fee(self, price: float, i: dict):
        #10**(-18)*math.ceil(10**18 *
        FeesTees = 0.0005
        liquidityAmount1 = self._pool_position._token1_amount *
(self._pool_position._price_upper**(0.5) *
self._pool_position._price_lower**(0.5)) /
(self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))
        liquidityAmount0 = self._pool_position._token0_amount /
(self._pool_position._price_upper**(0.5) -
self._pool_position._price_lower**(0.5))

        if price < self._pool_position._price_lower:
            deltaL = liquidityAmount0
```

```
        elif (self._pool_position._price_lower <= price) and (price <
self._pool_position._price_upper):
            deltaL = min(liquidityAmount0, liquidityAmount1)
        else:
            deltaL = liquidityAmount1
        self._pool_position._acc_fees += FeesTees *
self._states['volume24H'][i] * (deltaL/ (self._states['liquidity']
[i]*10**(-12) + deltaL))


    def calculate_std(self, timestamp: dt.datetime) -> float:
        lookback_period = self.params['Day']  # Ваш период в днях

        # Вычисляем начальную дату для фильтрации
        start_date = timestamp - timedelta(days=lookback_period)

        # Применяем фильтрацию к DataFrame self._states
        filtered_states = self._states[(self._states['datetime'] >=
start_date) & (self._states['datetime'] <= timestamp)]

        # Рассчитываем стандартное отклонение для 'token0Price' в
отфильтрованных данных
        std = abs(filtered_states['token0Price'].pct_change().std())
        return std




    def run(self):
        remember_price = None
        df_for_run = pd.DataFrame(self._states)
        for i, state in df_for_run.iterrows():
            if i < self.params['STD_TIMERANGE']:
            #print(f'Strategy | Skipping {state["datetime"]}')
                continue

            if not remember_price:
                remember_price = float(state['token0Price'])


            self._hedge.update_state(state['token0Price'],
state['fundingRate'])
            if self._pool_position:
                self._pool_position.update_state(state['token0Price'])
                self.update_fee(self._pool_position._price_current, i)
                if (self._pool_position._token0_amount *
self._pool_position._token1_amount == 0):
                    self.rebalance(state,True)
                    remember_price = None
                if not remember_price:
```

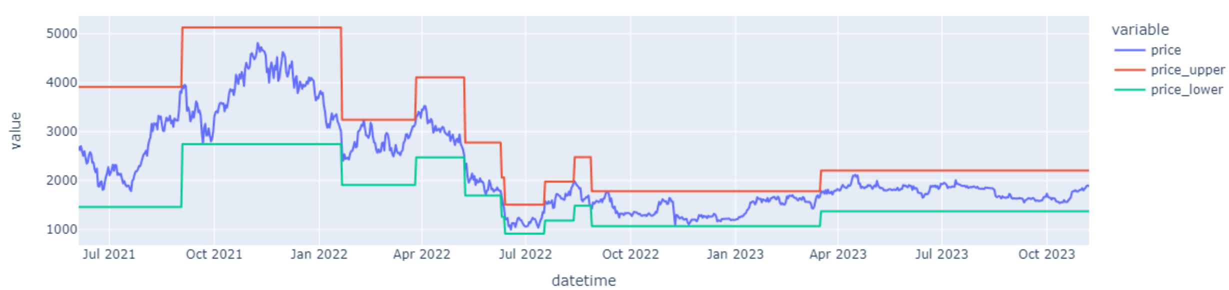
```
                    remember_price = float(state['token0Price'])
                if not (state['token0Price']*(1-self.params['Koef'])<=
remember_price <= (1+self.params['Koef']) * state['token0Price']):
                    self.rebalance(state, False)
                    remember_price = None
            else:
                self.rebalance(state, True)

            self._data.append([
                state['datetime'],
                state['token0Price'],
                self._pool_position.balance(),
                self._hedge.margin_balance(),
                self._pool_position.balance() +
self._hedge.margin_balance(),
                self._pool_position._price_upper,
                self._pool_position._price_lower,
            ])

        return pd.DataFrame(self._data, columns=['datetime', 'price',
'pool_balance', 'hedge_balance', 'total_balance', 'price_upper',
'price_lower'])

    def rebalance(self, state, bool):

            #print(f'Strategy | Start rebalancing at
{state["datetime"]}')

        std = self.calculate_std(state['datetime'])
            #print(f'Strategy | Calculated std {std}')

        if self._pool_position is not None:
            pool_balance: float = self._pool_position.balance() * (1 -
0.0005) # some fees and slippage
            self._hedge.close_position()
            equity: float = pool_balance +
self._hedge.margin_balance()
        else:
            equity: float = self.params['START_EQUITY']

        def is_valid_number(number):
            # Проверка на не NaN
            if np.isnan(number):
                return False
                # Проверка на не равно 0 и больше нуля
            if number > 0:
                return True
            return False
```

```
            #print("decim:",state['token0Price'] * (1 - std *
self.params['STD_COUNT']))


        if(self.params['Bool']):
            if(is_valid_number(state['token0Price'] * (1 - std *
self.params['STD_COUNT']))):
                r = math.sqrt((state['token0Price'] * (1 + std *
self.params['STD_COUNT']))/(state['token0Price'] * (1 - std *
self.params['STD_COUNT'])))
                H = (math.sqrt(r) - 1)/(r-1)
            else: H = self.params['H']
        else:
            H = self.params['H']
                #H =1/3


            # virtual witfhdraw and deposit for rebalancing capital
        self._hedge.withdraw(self._hedge.margin_balance())
        self._hedge.deposit(H * equity)

        if(bool):
            self._pool_position = create_position_by_notional(
                (1-H)*equity,
                price_current=state['token0Price'],
                price_upper=state['token0Price'] * (1 + std *
self.params['STD_COUNT']),
                price_lower=state['token0Price'] * (1 - std *
self.params['STD_COUNT']),
            )
        else:
            self._pool_position = create_position_by_notional(
                (1-H)*equity,
                price_current=state['token0Price'],
                price_upper = self._pool_position._price_upper,
                price_lower = self._pool_position._price_lower
            )


        self._hedge.open_position(
            size=-(self._pool_position.balance() / 2) /
state['token0Price'],
            entry_price=state['token0Price'],
        )



strategy = Strategy(all_data.sort_values('datetime').reset_index(), 5,
30, 1000000, 1,0.0001,True, 1000) #тут будет такая запись
Strategy(all_data.sort_values('datetime').reset_index(), 3, 30, S,
```

```
H,True)
data = strategy.run()


df = pd.DataFrame(data)


# scale all balances to first day
df['pool_balance'] = df['pool_balance'] / df['pool_balance'][0]
df['hedge_balance'] = df['hedge_balance'] / df['hedge_balance'][0]
df['total_balance'] = df['total_balance'] / df['total_balance'][0]
print("Income:",df['total_balance'].to_list()[-1])

px.line(df.sort_values('datetime'), x='datetime', y=['pool_balance',
'hedge_balance', 'total_balance'])
```

```
Income: 0.7747093822700238
```


```
px.line(df, x='datetime', y=['price', 'price_upper', 'price_lower'])
```

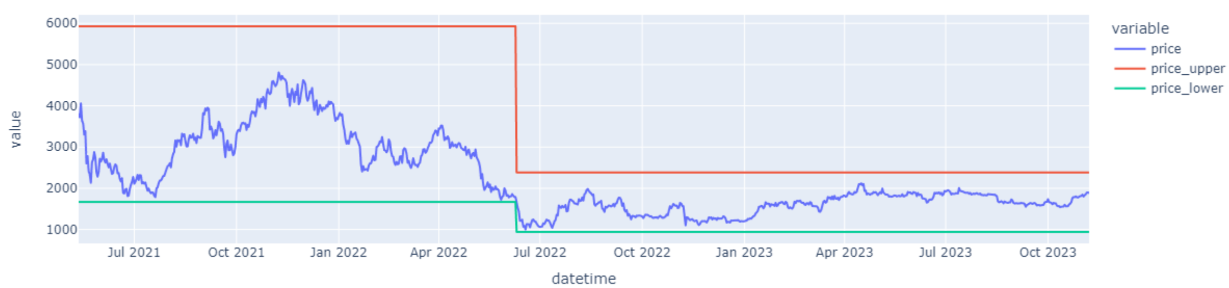



```
def what_last_total_balance(STD_COUNT,STD_TIMERANGE, START_EQUITY,
Koef,H, day)->float:
    strategy =
Strategy(all_data.sort_values('datetime').reset_index(), STD_COUNT,
STD_TIMERANGE, START_EQUITY, Koef, H, True, day) #False
```

```
    data = strategy.run()
    df = pd.DataFrame(data)

    # scale all balances to first day
    df['total_balance'] = df['total_balance'] / df['total_balance']
[0];
    return df['total_balance'].to_list()[-1];

#print(what_last_total_balance(5, 30, 100000, 1/3));

# Создайте массивы для каждого аргумента с использованием np.arange
arg1_values = np.arange(3,12)  # Например, для первого аргумента от 1
до 3
arg2_values = np.arange(5, 15, 2)  # Например, для второго аргумента
от 1 до 15, я проводил много раз бектест и понял что это оптимальный
промежуток, дальше 15 как правило ничего интересного нет
arg3_values = np.arange(0.0, 0.99, 0.09)
arg4_values = [30,60,90, 180, 1000]
H_values = [0.00001,1/3,1/5,1]

max_value = -np.inf
max_indices = (0, 0, 0,0, 0)



# Вычислите значение функции для каждой комбинации аргументов
for arg1 in arg1_values:
    for arg2 in arg2_values:
        for arg3 in arg3_values:
            for arg4 in arg4_values:
                for H_value in H_values:
                    result = what_last_total_balance(arg1, arg2,
100000, arg3, H_value,arg4)
                    if result > max_value:
                        max_value = result
                        max_indices = (arg1, arg2, arg3,arg4,H_value)

arg1 = max_indices[0]
arg2 = max_indices[1]
arg3 = max_indices[2]
arg4 = max_indices[3]
arg5 = max_indices[4]

print(f"Максимальное значение функции: {max_value}")
print(f"Индексы, где оно достигается: Std_Count={max_indices[0]},
Time_Range={max_indices[1]}, koef={max_indices[2]},
sigma_mode_day={max_indices[3]}, H={max_indices[4]}")
```

```
Максимальное значение функции: 1.1347897266169231
Индексы, где оно достигается: Std_Count=9, Time_Range=7, koef=0.63,
sigma_mode_day=1000, H=1e-05

print("Income:",what_last_total_balance(arg1, arg2, 100000, arg3,
arg5, arg4))
# you can take filtered data

strategy = Strategy(all_data.sort_values('datetime').reset_index(),
arg1, arg2, 100000, arg3, arg5, True,arg4)
data = strategy.run()

df = pd.DataFrame(data)

# scale allalances to first day
df['pool_balance'] = df['pool_balance'] / df['pool_balance'][0]
df['hedge_balance'] = df['hedge_balance'] / df['hedge_balance'][0]
df['total_balance'] = df['total_balance'] / df['total_balance'][0]

px.line(df.sort_values('datetime'), x='datetime', y=['pool_balance',
'hedge_balance', 'total_balance'])

Income: 1.1347897266169231
```


```
px.line(df, x='datetime', y=['price', 'price_upper', 'price_lower'])
```



Сценарное Моделирование

Чтож, из этого следует что на самом деле выгоднее всего использовать модель, предложенную на

Ну а теперь самое интересное, каким образом нам подбирать требуемые значения? Для этого предлагаю сгенерировать 100 траекторий, а затем оценить доходность на них, каким же образом мы будем оценивать доходности?

На самом деле вопрос абсолютно не тривиальный, так как положим у нас есть траектория которая даёт доходность 0.5, а другая 10, а другая стратегия даёт выгоду 1 и 1.2, как тогда определить наилучший?

Положим у нас есть доходности: $\left[a_1, \ldots, a_n\right]$, будто бы разумно сказать, что это некоторая выборка случайной величины $e^{\xi(\theta)}$, тогда очевидно нам хотелось бы чтобы наша $\xi(\theta)$ имела маленькую дисперсию и желательно положительное значение, я пока не изучал то, как задаются функции полезности для стратегий, поэтому строгого доказательства такой "оптимизации" не будет, поскольку она исходит из моих математических интуиций.

Так мы плавно переходим к Монте-Карло, посмотрев на модель геометрически-броуновского движения цены пониманием, что нам для начала высчитывать волатильность цены, для этого мы пробегаем по траектории цены и с окном в 30 дней, то есть мы смотрим на график цены, на -14 и +14 дней от него и из этого считаем волатильность, теперь давайте сгенерируем траектории, которые начинаются в $df['token0Price'][0]$ и будем задавать наши траектории как последовательную сумму случайных гауссовских величин с $\mu=0$ и $\sigma=df['volatility'][i]$

Собственно для оценки волатильности воспользуемся лог-ретёрнами, затем находим дисперцию, делим на количество записей и получаем σ согласно модели геометрического-броуновского движения

$$S_t = S_0 exp\left(\left(\mu - \frac{\sigma^2}{2}\right)t + \sigma W_t\right)$$

$$S_{t+1} = S_0 exp\left(\left(\mu - \frac{\sigma^2}{2}\right)(t+1) + \sigma W_{t+1}\right)$$

$$log_{return} = ln¿$$

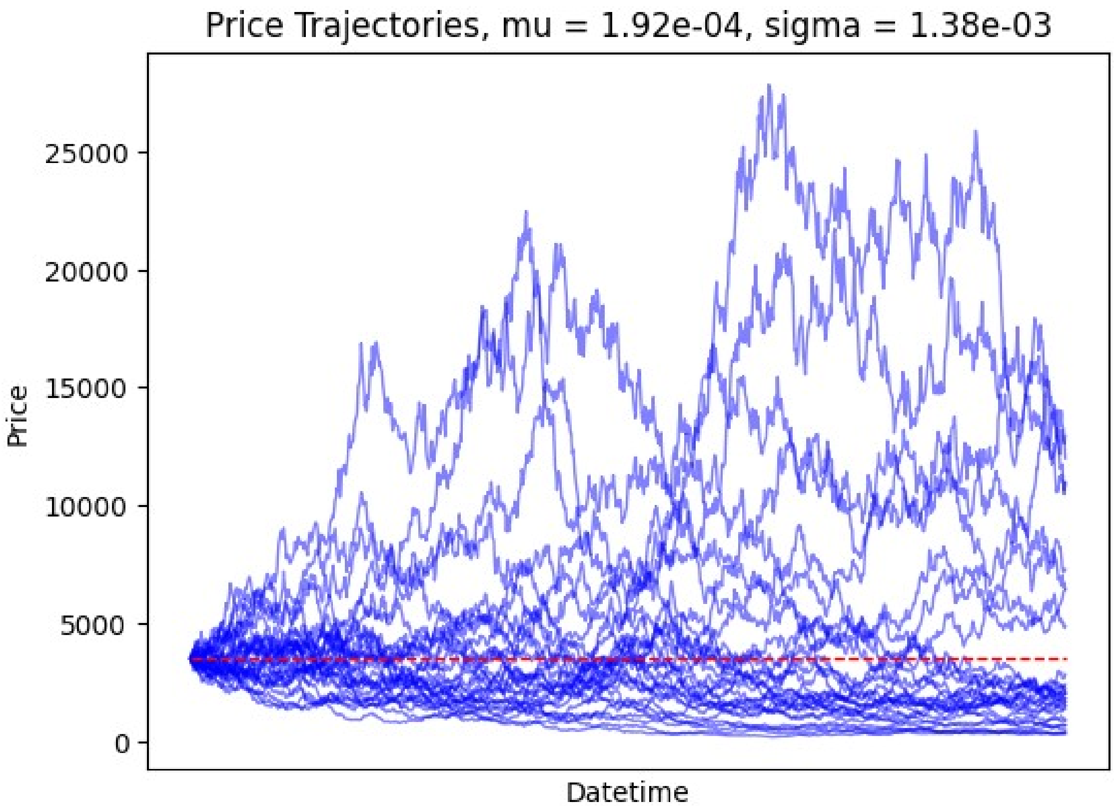
$$Var(log_{return}) = \sigma^2$$

$$E(log_{return}) = \mu - \frac{\sigma^2}{2}$$

$$\mu = E(log_{return}) + \frac{Var(log_{return})}{2}$$

```
df = pd.DataFrame(all_data)

# Calculate log-returns for the 'token0Price' column
df['Log_Returns'] = np.log(df['token0Price'] /
df['token0Price'].shift(1))

# Remove the first row since log-returns are not defined for it
df = df.dropna()

# Check if the DataFrame is empty
if not df.empty:
    # Calculate the variance of Log_Returns
    variance = df['Log_Returns'].var()
    matexp = df['Log_Returns'].mean()
    # Set the number of trajectories
    num_trajectories = 30

    # Create a function to generate a trajectory
    def generate_trajectory(num_steps, initial_price, mu, sigma):
        time_points = np.arange(num_steps)
        random_steps = np.random.normal(0, 1, num_steps)
        random_steps[0] = 0
        trajectory = initial_price * np.exp((mu - sigma**2/2) *
time_points + sigma * np.cumsum(random_steps))
        return trajectory

    # Set the parameters for the trajectories
    initial_price = df['token0Price'].iloc[0]  # Use .iloc[0] to
access the first element

    sigma = np.sqrt(variance / len(df['Log_Returns']))  # Calculate
sigma from variance
    mu = matexp + variance/2

    # Set the number of time steps
    num_steps = len(df)

    # Create an empty DataFrame for storing trajectories
    trajectories = pd.DataFrame()

    # Add the 'data' column to the 'trajectories'
    trajectories['datetime'] = df['datetime']

    # Create a 'Time' column with time points
    trajectories['Time'] = np.arange(num_steps)

    # Generate trajectories and add them to the DataFrame
    for i in range(num_trajectories):
```

```
        trajectory = generate_trajectory(num_steps, initial_price, mu, 
math.sqrt(sigma))
        column_name = f'Trajectory_{i + 1}'
        trajectories[column_name] = trajectory


else:
    print("DataFrame 'df' is empty.")

# Create a plot for each trajectory
for i in range(min(num_trajectories,30)):
    column_name = f'Trajectory_{i + 1}'
    plt.plot(trajectories['datetime'], trajectories[column_name], 
label=f'Trajectory {i + 1}', color='blue', linewidth=1, alpha=0.5)

constant_trajectory = [initial_price] * num_steps
plt.plot(trajectories['datetime'], constant_trajectory, 
label='Constant Trajectory', color='red', linestyle='--', linewidth=1)


# Set labels and title
plt.xlabel('Datetime')
plt.ylabel('Price')
plt.title(f'Price Trajectories, mu = {mu:.2e}, sigma = {sigma:.2e}')

plt.xticks([])
# Show a legend

# Display the plot
plt.show()
```



Окей, мы сгенерировали 30 траекторий, теперь напишем функцию для оценки доходности

```
def what_last_total_balance(all_data, STD_COUNT,STD_TIMERANGE,
START_EQUITY, Koef,H, day, bool)->float:
    strategy =
Strategy(all_data.sort_values('datetime').reset_index(), STD_COUNT,
STD_TIMERANGE, START_EQUITY, Koef, H, bool, day) #False
    data = strategy.run()
    df = pd.DataFrame(data)

    # scale all balances to first day
    df['total_balance'] = df['total_balance'] / df['total_balance']
[0];
    return df['total_balance'].to_list()[-1];
```

Теперь собственно проведем оптимизацию, будем оцевать вариацию ряда из логарифмов нашей итоговой доходности и надеятся на то, что будет стратегия с положительным мат. ожиданием

```
trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
```

```
arg1_values = [0.1, 0.25, 0.5, 1, 3, 5, 8]  # Например, для первого
аргумента от 1 до 3
arg2_values = np.arange(5, 13, 2)  # Например, для второго аргумента
от 1 до 13, я проводил много раз бектест и понял что это оптимальный
промежуток, дальше 15 как правило ничего интересного нет
original_array = np.arange(0.05, 0.46, 0.1)
arg3_values = np.append(original_array, 1)
# arg3_values = (np.arange(0.01, 0.63, 0.09)).append([1])
arg4_values = [1000]
H_values = [0.00001,1/3,1/5,1]

min_value_var = np.inf
max_value_exp = -np.inf
min_indices_var = (0, 0, 0, 0, 0, 0,0)
max_indices_exp = (0, 0, 0, 0, 0, 0,0)

# Вычислите значение функции для каждой комбинации аргументов
for arg1 in arg1_values:
    for arg2 in arg2_values:
        for arg3 in arg3_values:
            for arg4 in arg4_values:
                for H_value in H_values:
                    result = np.array([])
                    for keys_name in trajectories_copy.keys():
                        all_data_copy = all_data.copy()  # Get the
last value to append
                        all_data_copy['token0Price'] =
trajectories_copy[keys_name] #initial_price
                        all_data_copy['token0Price'][0] =
all_data['token0Price'][0]
                        result = np.append(result,
what_last_total_balance(all_data_copy, arg1, arg2, 100000, arg3,
H_value, arg4, True))
                    result_var = (np.log(result)).var()
                    result_mean = np.log(result).mean()
                    if result_var < min_value_var:
                        min_value_var = result_var
                        min_indices_var = (arg1, arg2, arg3,arg4,
H_value, math.e**result_mean,result_var)

                    if result_mean > max_value_exp:
                        max_value_exp = result_mean
                        max_indices_exp = (arg1, arg2, arg3,arg4,
H_value, math.e**result_mean,result_var)


print("Если мы максимизируем по ожиданию:")
print(f"Вариация:{max_indices_exp[6]}, Мат.Ожидание:
{max_indices_exp[5]}\nИндексы, где оно достигается:
Std_Count={max_indices_exp[0]}, Time_Range={max_indices_exp[1]}, H =
```

```
{max_indices_exp[4]},koef={max_indices_exp[2]},
sigma_mode_day={max_indices_exp[3]}\n")


print("Если мы минимизируем по вариации:")
print(f"Вариация:{min_indices_var[6]}, Мат.Ожидание:
{min_indices_var[5]}\nИндексы, где оно достигается:
Std_Count={min_indices_var[0]}, Time_Range={min_indices_var[1]}, H =
{min_indices_var[4]}, koef={min_indices_var[2]},
sigma_mode_day={min_indices_var[3]}")
```

```
Если мы максимизируем по ожиданию:
Вариация:0.021304581071891766, Мат.Ожидание:0.721777210364004
Индексы, где оно достигается: Std_Count=8, Time_Range=7, H = 1e-
05,koef=1.0, sigma_mode_day=1000

Если мы минимизируем по вариации:
Вариация:0.014126302406034897, Мат.Ожидание:0.5413113168834935
Индексы, где оно достигается: Std_Count=5, Time_Range=5, H = 1e-05,
koef=0.05, sigma_mode_day=1000
```

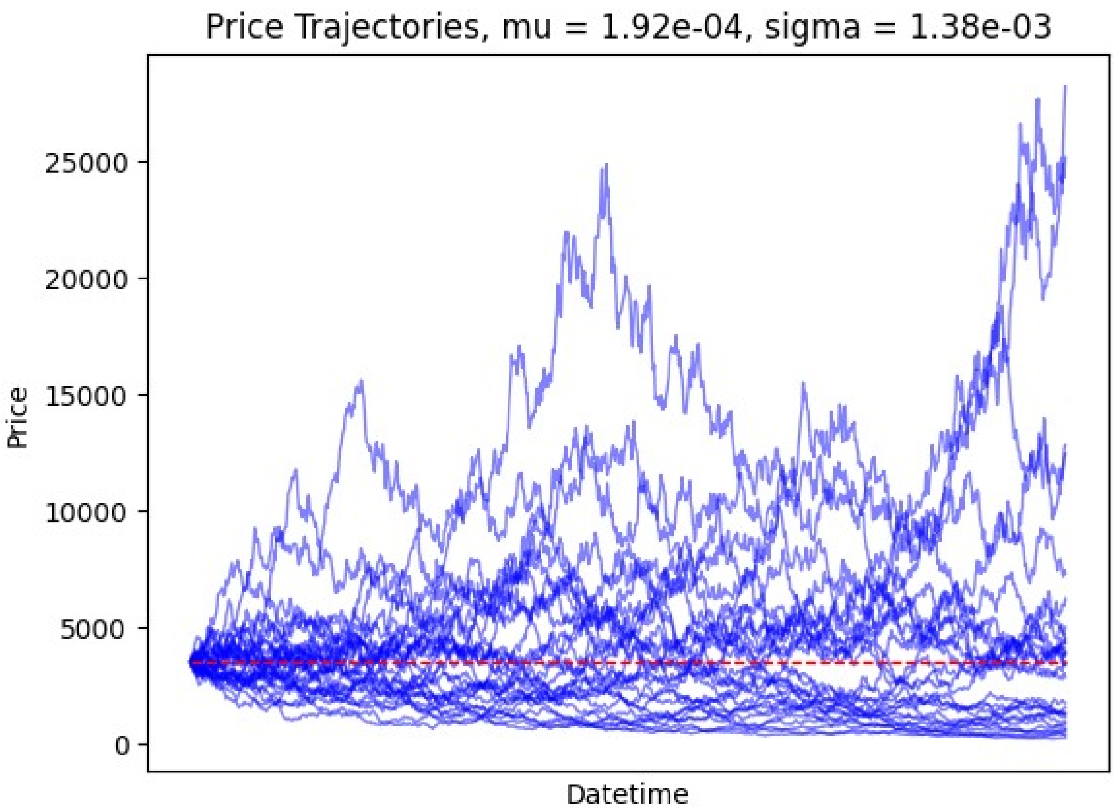
Теперь посмотрим как эти стратегии себя ведут и сравним их с изначальной. Сейчас я буду создавать 1000 траекторий, сначала это будет обычная модель с теме же значениями на которых выборка тренировалась, затем 3 предложенные в домашней работе стратегии: бычий тренд, медвежий и флэт. В качестве иллюстраций будет приводить распределение доходностей, которые получил от стратегии на этих 1000 траекториях.

Сначала будет стратегия минимизации вариации, затем максимизации мат.ожидания, а в конце изначальная стратегия, которая была предложена на семинаре (как я и обещал в одной из ячеек выше при помощи параметров можно было задать изначальную стратегию.

```
df = pd.DataFrame(all_data)

# Calculate log-returns for the 'token0Price' column
df['Log_Returns'] = np.log(df['token0Price'] /
df['token0Price'].shift(1))

# Remove the first row since log-returns are not defined for it
df = df.dropna()

# Check if the DataFrame is empty
if not df.empty:
    # Calculate the variance of Log_Returns
    variance = df['Log_Returns'].var()
    matexp = df['Log_Returns'].mean()
    # Set the number of trajectories
    num_trajectories = 1000
```

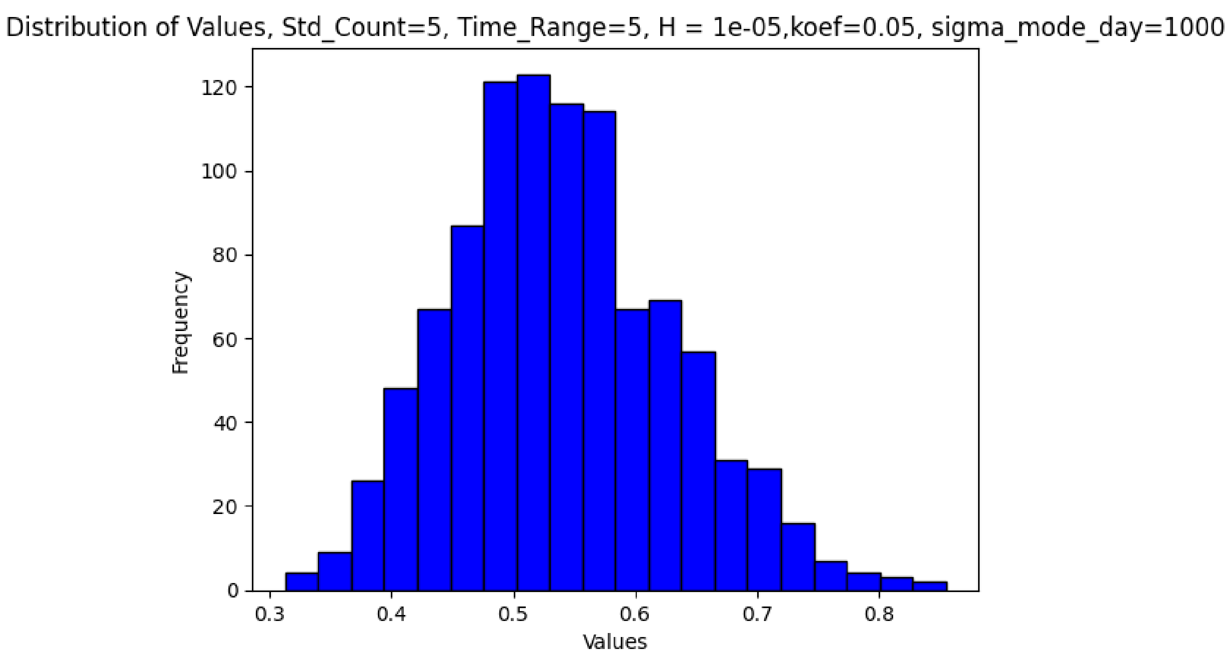
```
    # Create a function to generate a trajectory
    def generate_trajectory(num_steps, initial_price, mu, sigma):
        time_points = np.arange(num_steps)
        random_steps = np.random.normal(0, 1, num_steps)
        random_steps[0] = 0
        trajectory = initial_price * np.exp((mu - sigma**2/2) *
time_points + sigma * np.cumsum(random_steps))
        return trajectory

    # Set the parameters for the trajectories
    initial_price = df['token0Price'].iloc[0]  # Use .iloc[0] to
access the first element

    sigma = np.sqrt(variance / len(df['Log_Returns']))  # Calculate
sigma from variance
    mu = matexp + variance/2
    #pritn(mu)

    # Set the number of time steps
    num_steps = len(df)

    # Create an empty DataFrame for storing trajectories
    trajectories = pd.DataFrame()

    # Add the 'data' column to the 'trajectories'
    trajectories['datetime'] = df['datetime']

    # Create a 'Time' column with time points
    trajectories['Time'] = np.arange(num_steps)

    # Generate trajectories and add them to the DataFrame
    for i in range(num_trajectories):
        trajectory = generate_trajectory(num_steps, initial_price, mu,
math.sqrt(sigma))
        column_name = f'Trajectory_{i + 1}'
        trajectories[column_name] = trajectory


else:
    print("DataFrame 'df' is empty.")

# Create a plot for each trajectory
for i in range(min(num_trajectories,30)):
    column_name = f'Trajectory_{i + 1}'
    plt.plot(trajectories['datetime'], trajectories[column_name],
label=f'Trajectory {i + 1}', color='blue', linewidth=1, alpha=0.5)

constant_trajectory = [initial_price] * num_steps
plt.plot(trajectories['datetime'], constant_trajectory,
label='Constant Trajectory', color='red', linestyle='--', linewidth=1)
```

```
# Set labels and title
plt.xlabel('Datetime')
plt.ylabel('Price')
plt.title(f'Price Trajectories, mu = {mu:.2e}, sigma = {sigma:.2e}')

plt.xticks([])
# Show a legend

# Display the plot
plt.show()
```

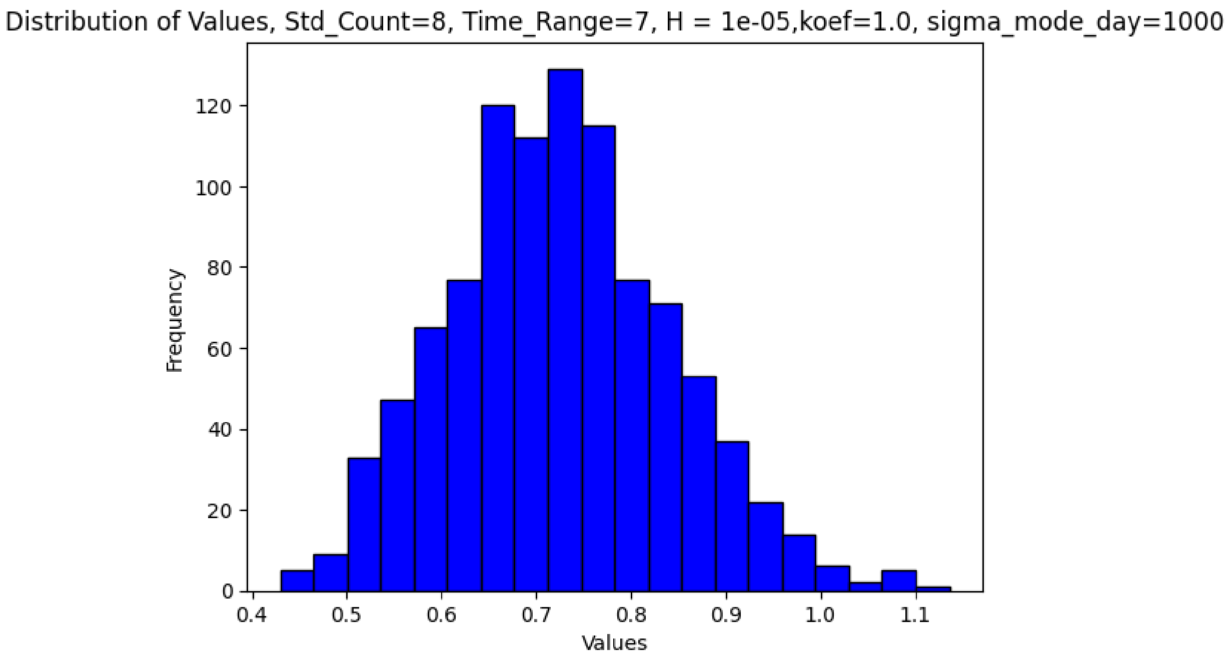



```
arg1 = min_indices_var[0]
arg2 = min_indices_var[1]
arg3 = min_indices_var[2]
arg4 = min_indices_var[3]
arg5 = min_indices_var[4]



trajectories_copy = trajectories.copy()
```

```
trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))



plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```

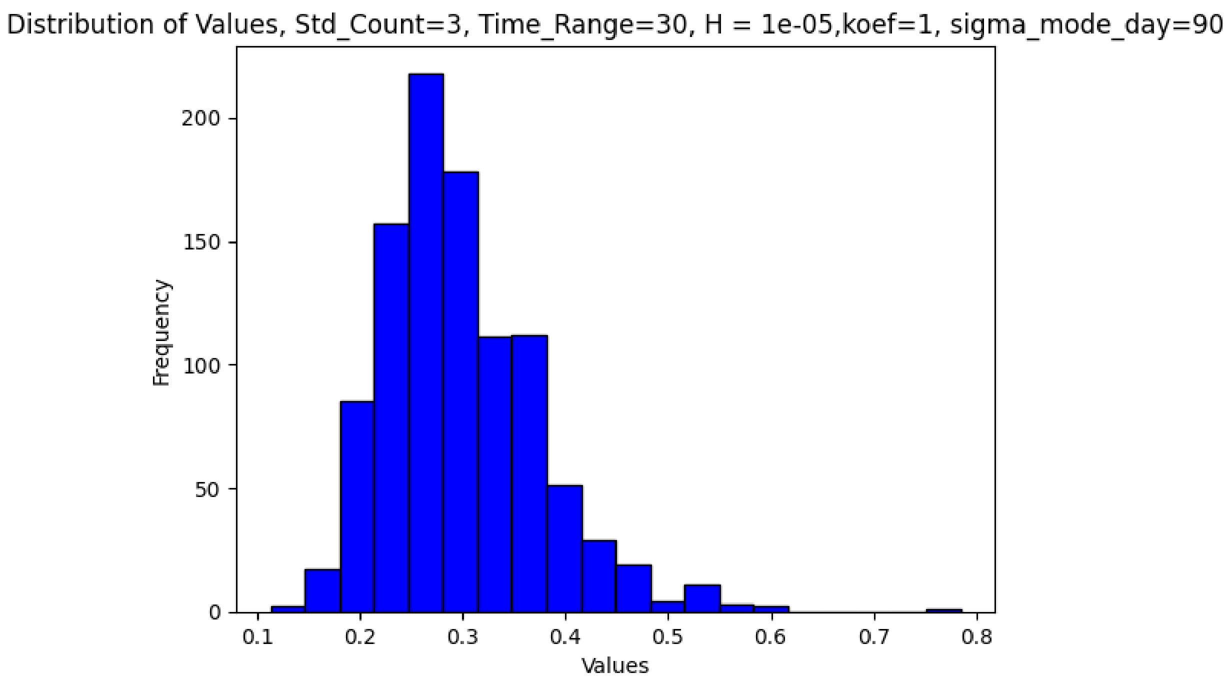


```
arg1 = max_indices_exp[0]
arg2 = max_indices_exp[1]
arg3 = max_indices_exp[2]
arg4 = max_indices_exp[3]
arg5 = max_indices_exp[4]



trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))



plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```




```
arg1 = 3
arg2 = 30
arg3 = 1
arg4 = 90
H = 1/3

trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, H, arg4, False))



plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
```

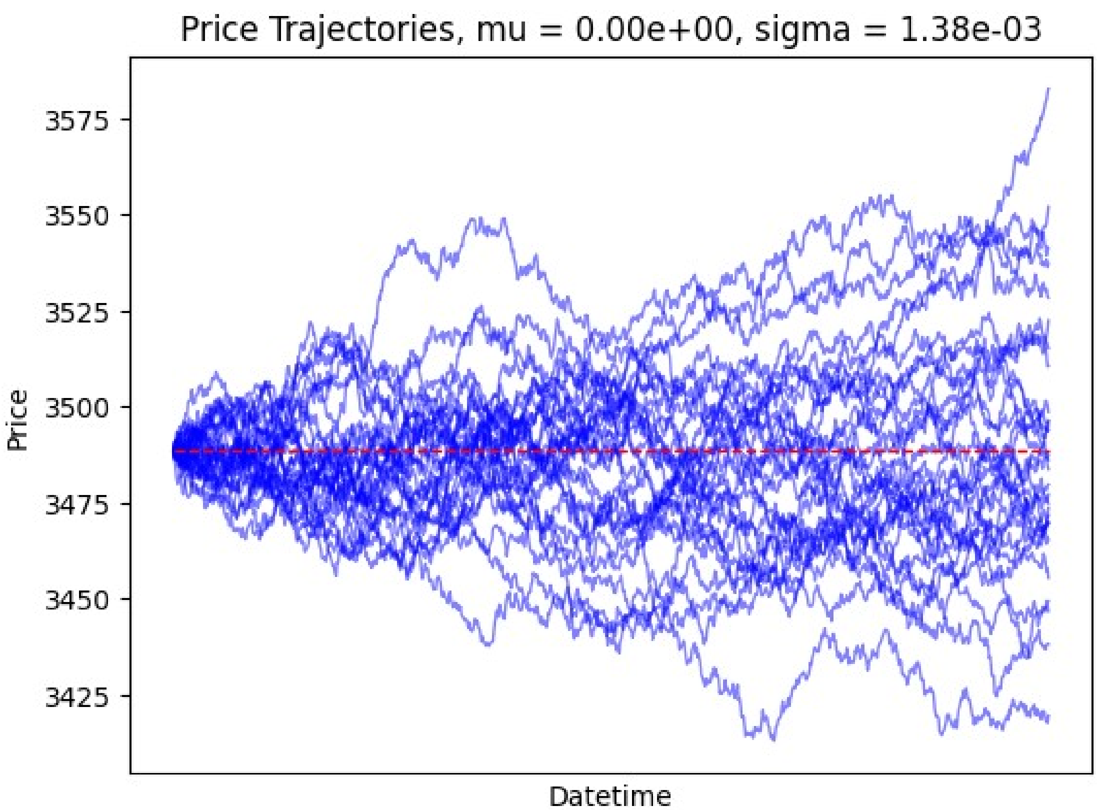
```
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```




```
df = pd.DataFrame(all_data)

# Calculate log-returns for the 'token0Price' column
df['Log_Returns'] = np.log(df['token0Price'] /
df['token0Price'].shift(1))

# Remove the first row since log-returns are not defined for it
df = df.dropna()

# Check if the DataFrame is empty
if not df.empty:
    # Calculate the variance of Log_Returns
    variance = df['Log_Returns'].var()

    # Set the number of trajectories
    num_trajectories = 1000

    # Create a function to generate a trajectory
    def generate_trajectory(num_steps, initial_price, mu, sigma):
        time_points = np.arange(num_steps)
```

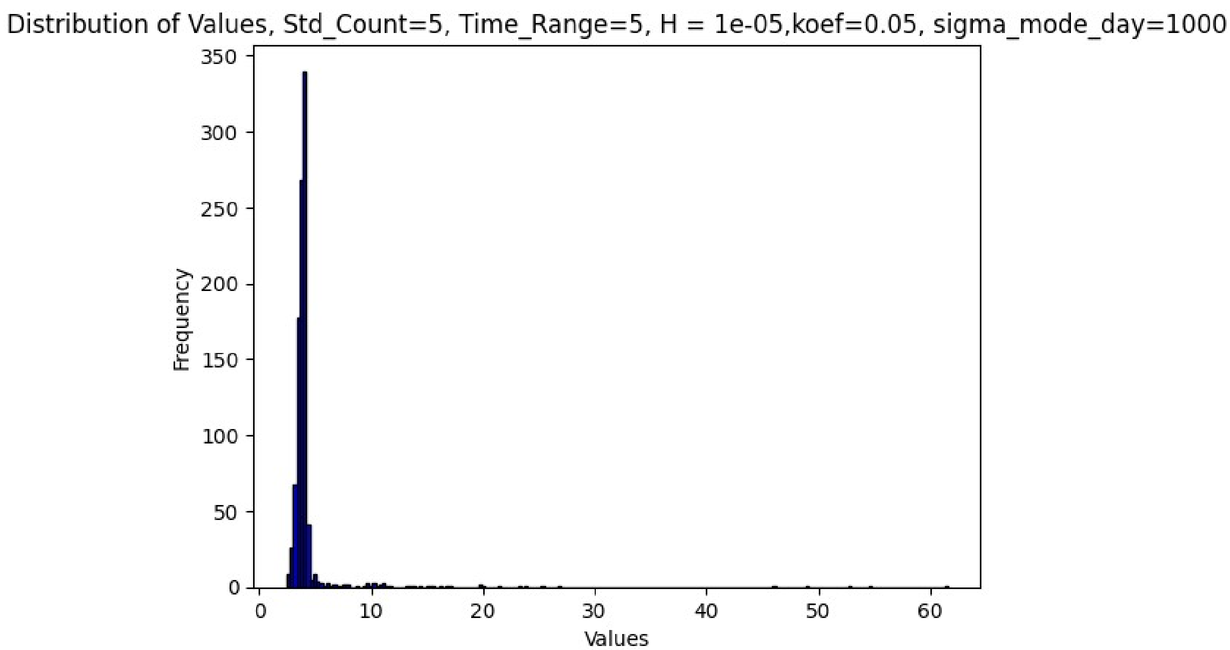
```
        random_steps = np.random.normal(0, 1, num_steps)
        random_steps[0] = 0
        trajectory = initial_price * np.exp((mu - sigma**2/2) *
time_points + sigma * np.cumsum(random_steps))
        return trajectory

    # Set the parameters for the trajectories
    initial_price = df['token0Price'].iloc[0]  # Use .iloc[0] to
access the first element
    mu = 0  # Set mu
    sigma = np.sqrt(variance / len(df['Log_Returns']))  # Calculate
sigma from variance

    # Set the number of time steps
    num_steps = len(df)

    # Create an empty DataFrame for storing trajectories
    trajectories = pd.DataFrame()

    # Add the 'data' column to the 'trajectories'
    trajectories['datetime'] = df['datetime']

    # Create a 'Time' column with time points
    trajectories['Time'] = np.arange(num_steps)

    # Generate trajectories and add them to the DataFrame
    for i in range(num_trajectories):
        trajectory = generate_trajectory(num_steps, initial_price, mu,
math.sqrt(sigma)/10**2)
        column_name = f'Trajectory_{i + 1}'
        trajectories[column_name] = trajectory


else:
    print("DataFrame 'df' is empty.")

# Create a plot for each trajectory
for i in range(min(num_trajectories,30)):
    column_name = f'Trajectory_{i + 1}'
    plt.plot(trajectories['datetime'], trajectories[column_name],
label=f'Trajectory {i + 1}', color='blue', linewidth=1, alpha=0.5)

constant_trajectory = [initial_price] * num_steps
plt.plot(trajectories['datetime'], constant_trajectory,
label='Constant Trajectory', color='red', linestyle='--', linewidth=1)


# Set labels and title
plt.xlabel('Datetime')
plt.ylabel('Price')
plt.title(f'Price Trajectories, mu = {mu:.2e}, sigma = {sigma:.2e}')
```

```
plt.xticks([])
# Show a legend

# Display the plot
plt.show()
```



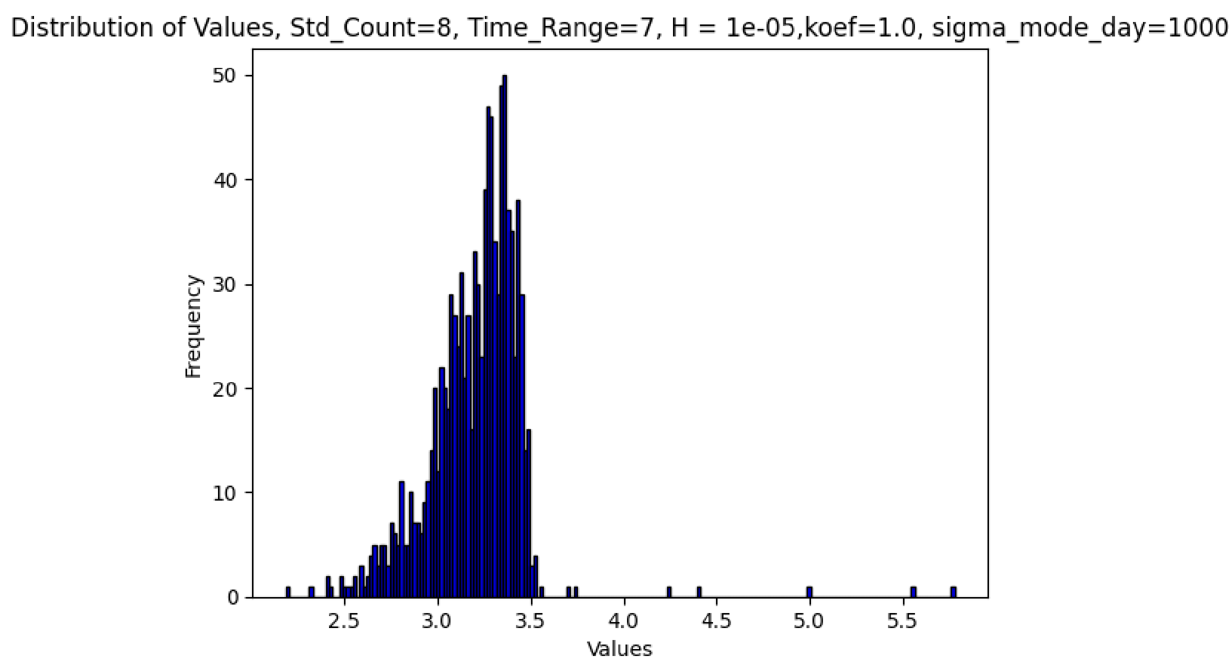

```
arg1 = min_indices_var[0]
arg2 = min_indices_var[1]
arg3 = min_indices_var[2]
arg4 = min_indices_var[3]
arg5 = min_indices_var[4]



trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
```

```
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))



plt.hist(result, bins=200, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```



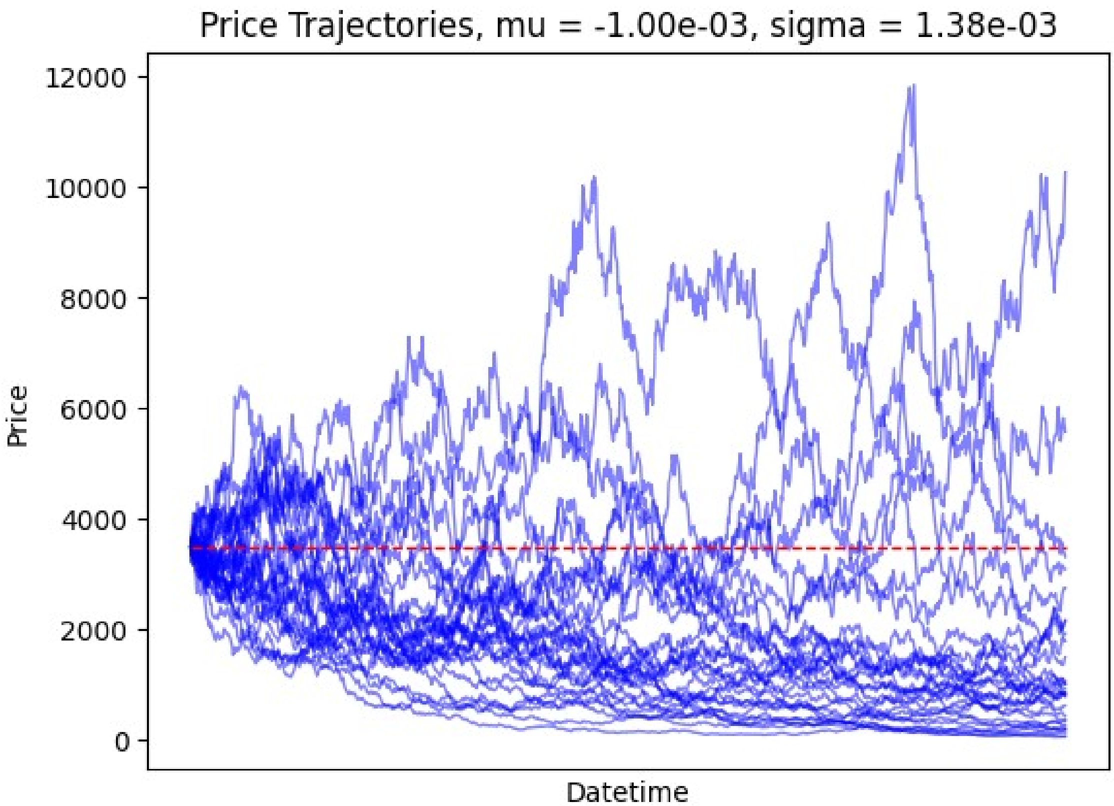

```
arg1 = max_indices_exp[0]
arg2 = max_indices_exp[1]
arg3 = max_indices_exp[2]
arg4 = max_indices_exp[3]
arg5 = max_indices_exp[4]



trajectories_copy = trajectories.copy()
```

```
trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))



plt.hist(result, bins=200, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```



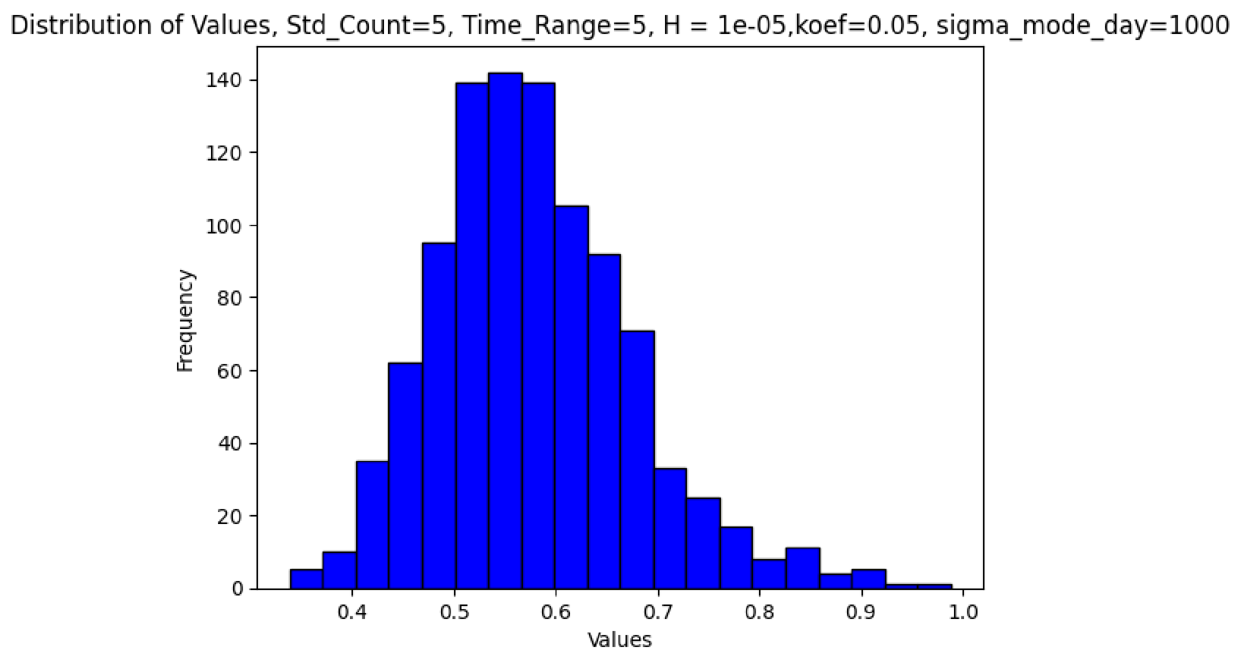
```
df = pd.DataFrame(all_data)

# Calculate log-returns for the 'token0Price' column
df['Log_Returns'] = np.log(df['token0Price'] /
df['token0Price'].shift(1))

# Remove the first row since log-returns are not defined for it
df = df.dropna()

# Check if the DataFrame is empty
if not df.empty:
    # Calculate the variance of Log_Returns
    variance = df['Log_Returns'].var()

    # Set the number of trajectories
    num_trajectories = 1000

    # Create a function to generate a trajectory
    def generate_trajectory(num_steps, initial_price, mu, sigma):
        time_points = np.arange(num_steps)
        random_steps = np.random.normal(0, 1, num_steps)
        random_steps[0] = 0
        trajectory = initial_price * np.exp((mu - sigma**2/2) *
time_points + sigma * np.cumsum(random_steps))
        return trajectory

    # Set the parameters for the trajectories
    initial_price = df['token0Price'].iloc[0]
    mu = -1/10**3  # Set mu
    sigma = np.sqrt(variance / len(df['Log_Returns']))  # Calculate
sigma from variance

    # Set the number of time steps
    num_steps = len(df)

    # Create an empty DataFrame for storing trajectories
    trajectories = pd.DataFrame()

    # Add the 'data' column to the 'trajectories'
    trajectories['datetime'] = df['datetime']

    # Create a 'Time' column with time points
    trajectories['Time'] = np.arange(num_steps)

    # Generate trajectories and add them to the DataFrame
    for i in range(num_trajectories):
        trajectory = generate_trajectory(num_steps, initial_price, mu,
math.sqrt(sigma))
        column_name = f'Trajectory_{i + 1}'
        trajectories[column_name] = trajectory
```

```
    # Display the generated trajectories with the 'data' column
    #print(trajectories)

else:
    print("DataFrame 'df' is empty.")

# Create a plot for each trajectory
for i in range(min(num_trajectories,30)):
    column_name = f'Trajectory_{i + 1}'
    plt.plot(trajectories['datetime'], trajectories[column_name],
label=f'Trajectory {i + 1}', color='blue', linewidth=1, alpha=0.5)

constant_trajectory = [initial_price] * num_steps
plt.plot(trajectories['datetime'], constant_trajectory,
label='Constant Trajectory', color='red', linestyle='--', linewidth=1)


# Set labels and title
plt.xlabel('Datetime')
plt.ylabel('Price')
plt.title(f'Price Trajectories, mu = {mu:.2e}, sigma = {sigma:.2e}')

plt.xticks([])
# Show a legend

# Display the plot
plt.show()
```



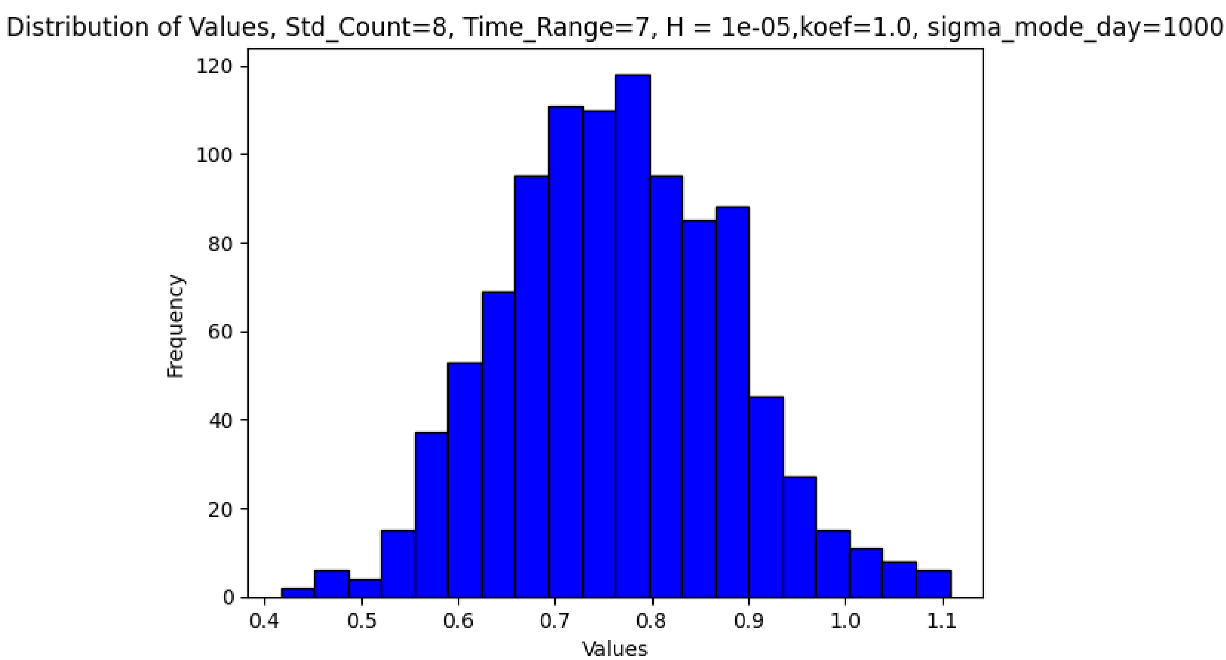

```
arg1 = min_indices_var[0]
arg2 = min_indices_var[1]
arg3 = min_indices_var[2]
arg4 = min_indices_var[3]
arg5 = min_indices_var[4]



trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))
```

```python
plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1}, 
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```



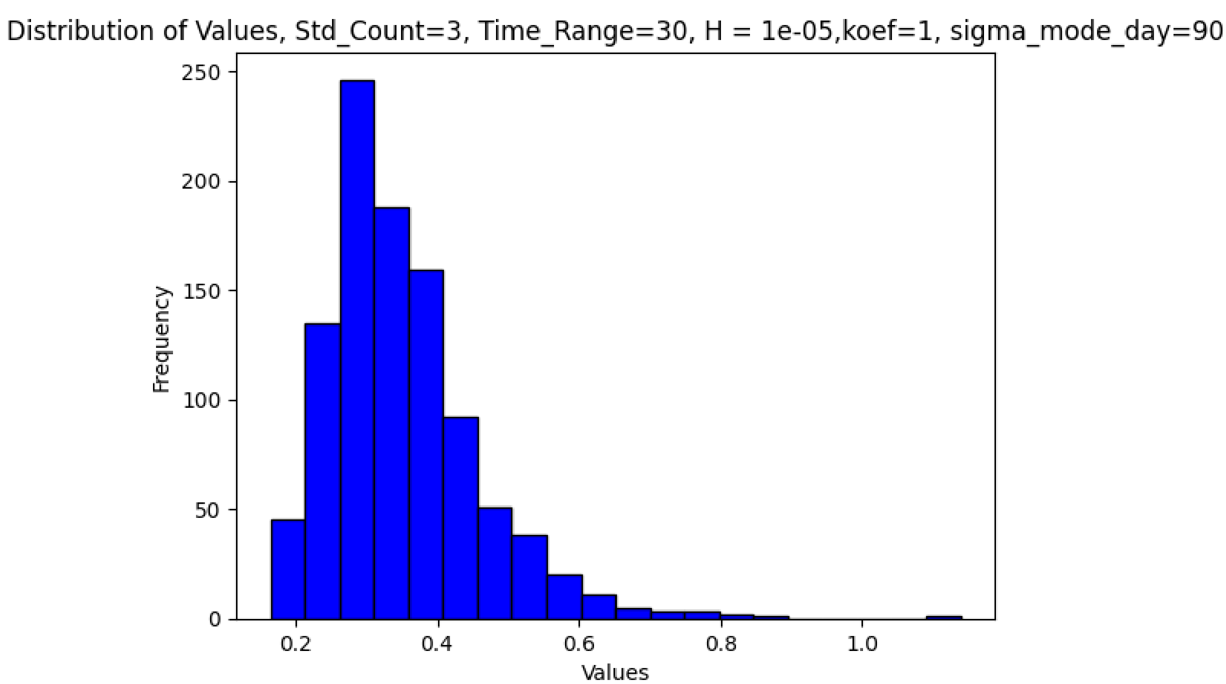

```python
arg1 = max_indices_exp[0]
arg2 = max_indices_exp[1]
arg3 = max_indices_exp[2]
arg4 = max_indices_exp[3]
arg5 = max_indices_exp[4]



trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
```

```
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))



plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')
# Show the plot
plt.show()
```



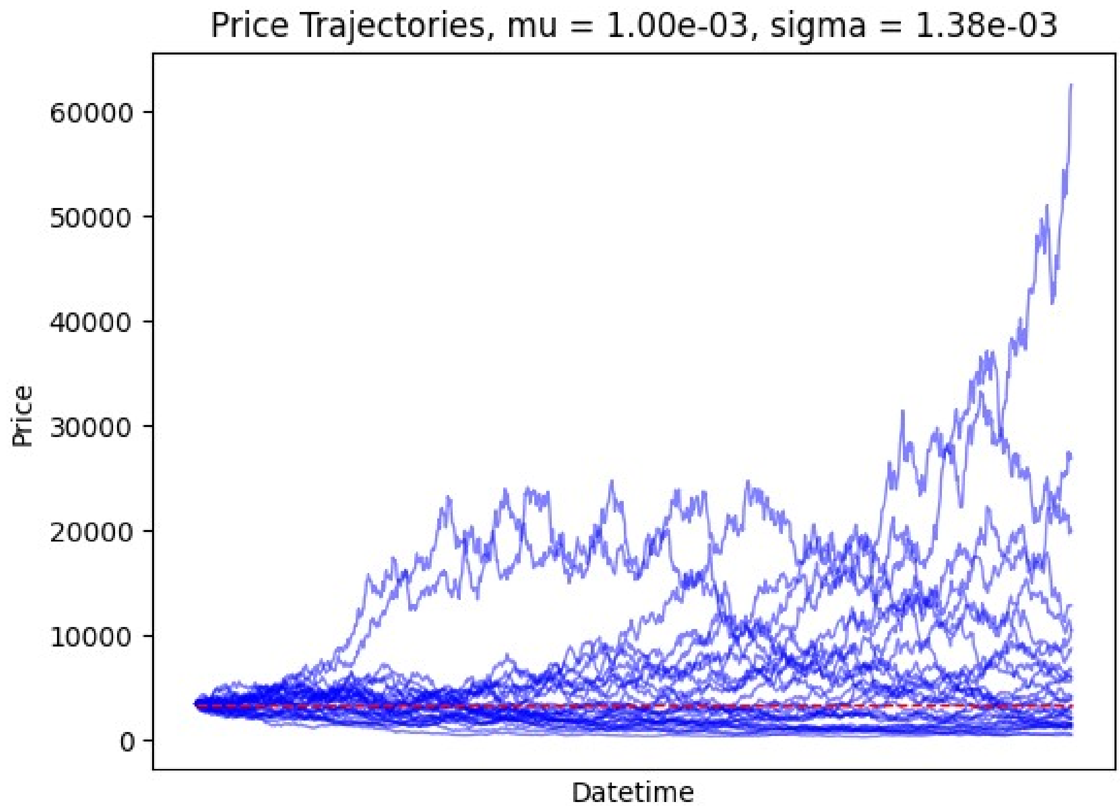

```
arg1 = 3
arg2 = 30
arg3 = 1
arg4 = 90
H = 1/3

trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
```

```
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, H, arg4, False))



plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
# Now, the 'token0Price' column in all_data contains the chosen
trajectory
```



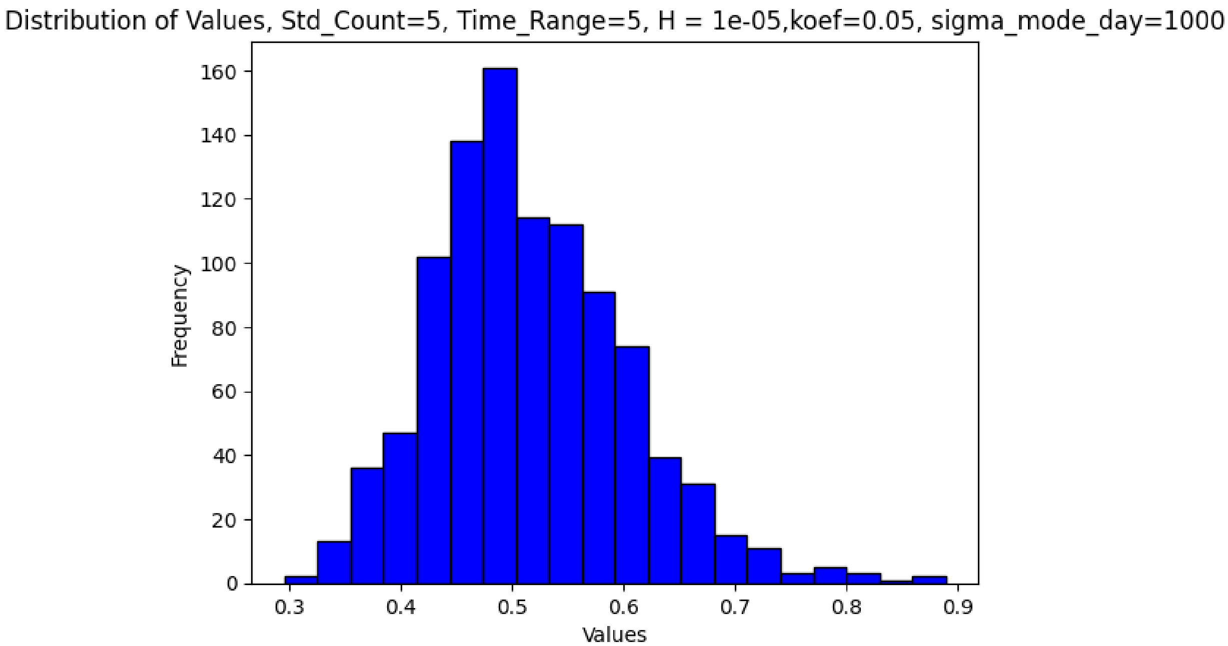
```
df = pd.DataFrame(all_data)

# Calculate log-returns for the 'token0Price' column
df['Log_Returns'] = np.log(df['token0Price'] /
df['token0Price'].shift(1))

# Remove the first row since log-returns are not defined for it
df = df.dropna()

# Check if the DataFrame is empty
if not df.empty:
    # Calculate the variance of Log_Returns
    variance = df['Log_Returns'].var()

    # Set the number of trajectories
    num_trajectories = 1000

    # Create a function to generate a trajectory
    def generate_trajectory(num_steps, initial_price, mu, sigma):
        time_points = np.arange(num_steps)
        random_steps = np.random.normal(0, 1, num_steps)
        random_steps[0] = 0
        trajectory = initial_price * np.exp((mu - sigma**2/2) *
time_points + sigma * np.cumsum(random_steps))
        return trajectory

    # Set the parameters for the trajectories
    initial_price = df['token0Price'].iloc[0]  # Use .iloc[0] to
access the first element
    mu = 1/10**3  # Set mu
    sigma = np.sqrt(variance / len(df['Log_Returns']))  # Calculate
sigma from variance

    # Set the number of time steps
    num_steps = len(df)

    # Create an empty DataFrame for storing trajectories
    trajectories = pd.DataFrame()

    # Add the 'data' column to the 'trajectories'
    trajectories['datetime'] = df['datetime']

    # Create a 'Time' column with time points
    trajectories['Time'] = np.arange(num_steps)

    # Generate trajectories and add them to the DataFrame
    for i in range(num_trajectories):
        trajectory = generate_trajectory(num_steps, initial_price, mu,
math.sqrt(sigma))
        column_name = f'Trajectory_{i + 1}'
```

```
        trajectories[column_name] = trajectory


else:
    print("DataFrame 'df' is empty.")

# Create a plot for each trajectory
for i in range(min(num_trajectories,30)):
    column_name = f'Trajectory_{i + 1}'
    plt.plot(trajectories['datetime'], trajectories[column_name],
label=f'Trajectory {i + 1}', color='blue', linewidth=1, alpha=0.5)

constant_trajectory = [initial_price] * num_steps
plt.plot(trajectories['datetime'], constant_trajectory,
label='Constant Trajectory', color='red', linestyle='--', linewidth=1)


# Set labels and title
plt.xlabel('Datetime')
plt.ylabel('Price')
plt.title(f'Price Trajectories, mu = {mu:.2e}, sigma = {sigma:.2e}')

plt.xticks([])
# Show a legend

# Display the plot
plt.show()
```



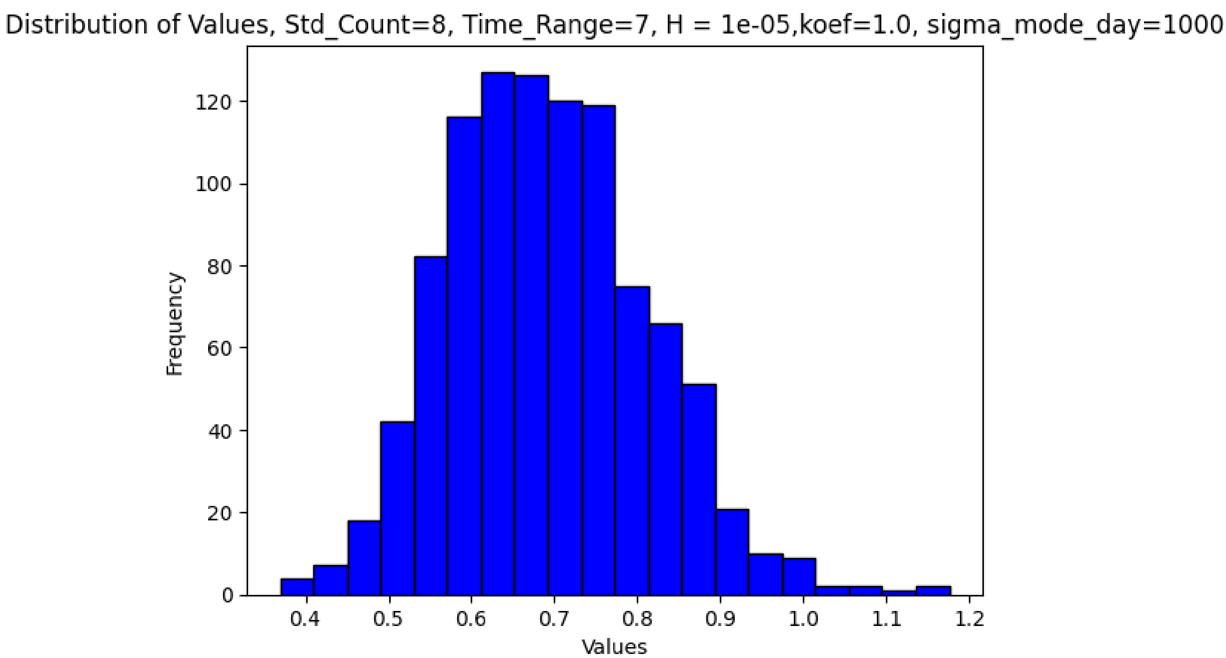

```
arg1 = min_indices_var[0]
arg2 = min_indices_var[1]
arg3 = min_indices_var[2]
arg4 = min_indices_var[3]
arg5 = min_indices_var[4]



trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))
```

```
plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```



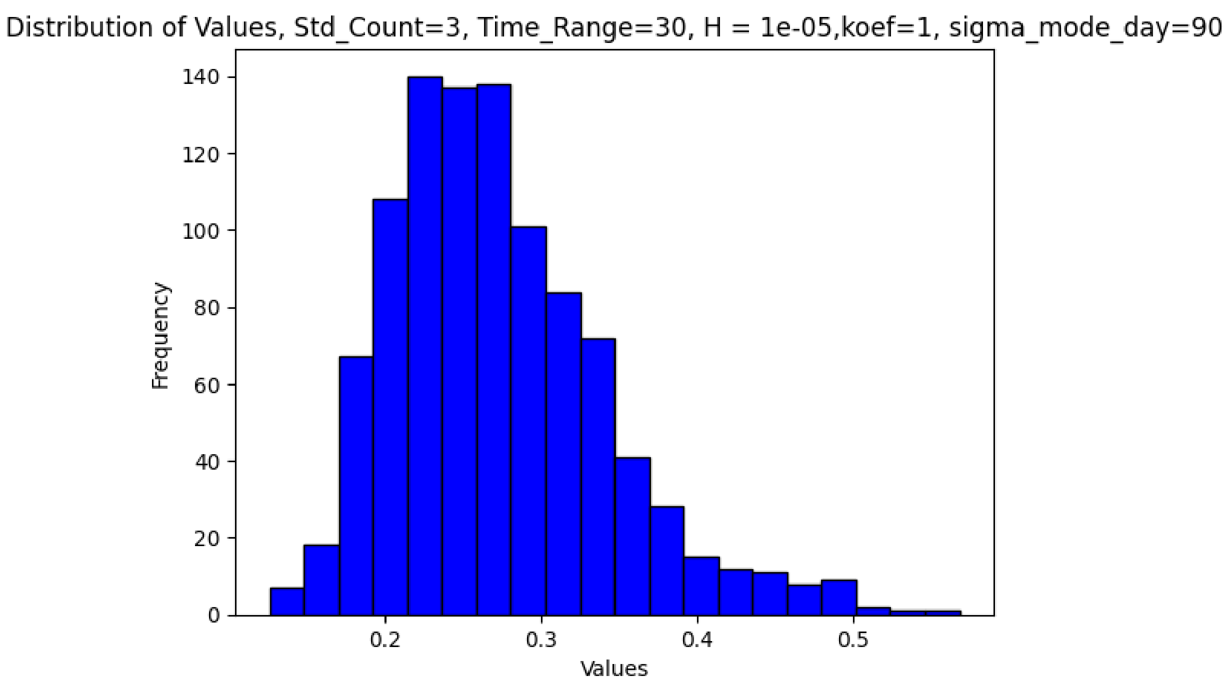

```
arg1 = max_indices_exp[0]
arg2 = max_indices_exp[1]
arg3 = max_indices_exp[2]
arg4 = max_indices_exp[3]
arg5 = max_indices_exp[4]



trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
```

```
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, arg5, arg4, True))



plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```




```
arg1 = 3
arg2 = 30
arg3 = 1
arg4 = 90
H = 1/3

trajectories_copy = trajectories.copy()

trajectories_copy = trajectories_copy.drop('datetime', axis=1)
```

```
trajectories_copy = trajectories_copy.drop('Time', axis=1)
#print(trajectories_copy)

result =np.array([])
for keys_name in trajectories_copy.keys():
    # print(all_data)
    all_data_copy = all_data.copy()  # Get the last value to append
    all_data_copy['token0Price'] = trajectories_copy[keys_name]
#initial_price
    all_data_copy['token0Price'][0] = all_data['token0Price'][0]
    result = np.append(result, what_last_total_balance(all_data_copy,
arg1, arg2, 100000, arg3, H, arg4, False))



plt.hist(result, bins=20, color='blue', edgecolor='black')

# Add labels and a title
plt.xlabel('Values')
plt.ylabel('Frequency')
plt.title(f'Distribution of Values, Std_Count={arg1},
Time_Range={arg2}, H = {arg5},koef={arg3}, sigma_mode_day={arg4}')

# Show the plot
plt.show()
```



Чтож, можно подытожить, что наша стратегия, скорее всего, на реальных данных будет убыточная, однако мы вдвое улучшили доходность стратегии, которая изначально была предложена на семинаре.