Math Methods for Financial Price Analysis

Professor Alexei Chekhlov

Final Project (Group E):

Yicheng Tang (yt2875)
Wanhe Yu (wy2433)
Yushan Zhang (yz4739)
Chuhe Liu (cl3828)
Ding Jin (dj2692)
Jinglong Xue (jx2548)
Siqi Yang (sy3153)
Xinyi Zhang (xz3294)
Chen Xu (cx2310)

Trend-Following Strategy in the Soybean Futures Market

Department of Mathematics at Columbia University

Our Future Markets

Primary: Soybeans (U.S.)

Blp Ticker: S TD Ticker: SY Data from Jul-82

Soybean futures (SY) started trading on the Chicago Board of Trade (now part of the CME Group) in 1936.

Secondary: No. 1 Soybean Futures (China)

Blp Ticker: AK TD Ticker: SOYBN Data from May-18

No. 1 Soybean Futures (SOYBN) trading began in 1994 with the establishment of the Dalian Commodity Exchange (DCE).

Introduction to Future Contract Specs

	SY	SOYBN
CONTRACT UNIT	5,000 bushels (~ 136 MT)	10 MT / Lot
PRICE QUOTATION	U.S. cents per bushel	CNY 1 per metric ton
MINIMUM PRICE FLUCTUATION (Tick Size)	1/4 of one cent (0.0025) per bushel = $12.50	1 Yuan per metric ton (CNY 10 per contract)
Daily Limit	95 cents per bushel ($4,750 per contract) Expanded limit $1.45	4% of last settlement price (temporarily 5%)
TERMINATION OF TRADING	15th day of the contract month.	10th Trading Day of the Delivery Month

TRADING HOURS	7:00 p.m. - 7:45a .m. and 8:30a.m. - 1:20p.m. (Settles 1:15p.m.) (Sun-Fri) CST	9:00a.m. - 11:30a.m. and 1:30 p.m. - 3:00 p.m. (Mon-Fri) Beijing
LISTED CONTRACTS	15 monthly contracts of Jan, Mar, May, Aug, Sep and 8 monthly contracts of Jul and Nov listed annually after the termination of trading in the November contract of the current year.	Jan, Mar, May, Jul, Sep, Nov (F, H, K, N, U, X)
SETTLEMENT METHOD	Deliverable	Physically delivered

Soybean futures are an easy, liquid tool for speculating or hedging against price movements for one of the world's most widely grown crops.

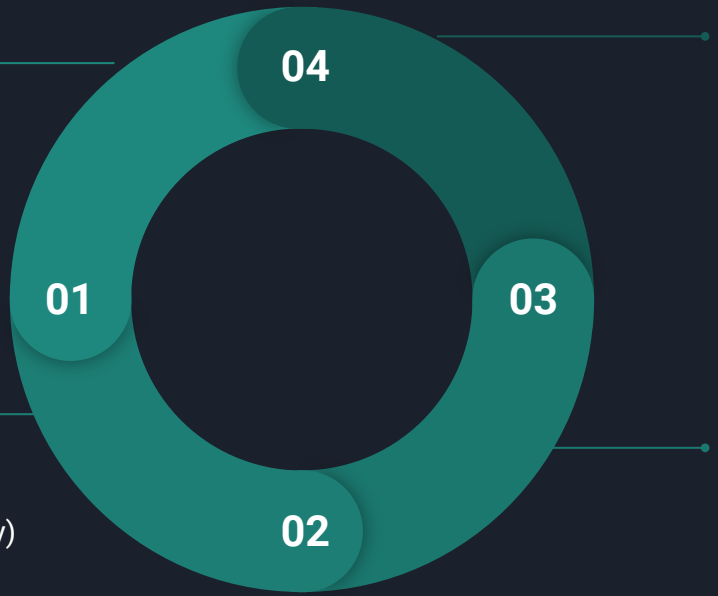
Factors Influencing Market Price

Supply

- Exporting countries: U.S., Brazil, Argentina.
- Sown area
- Yield
- Weather and pests diseases

Demand

- Importing countries: China, EU, Japan.
- Livestock production cycle (pigs and poultry)



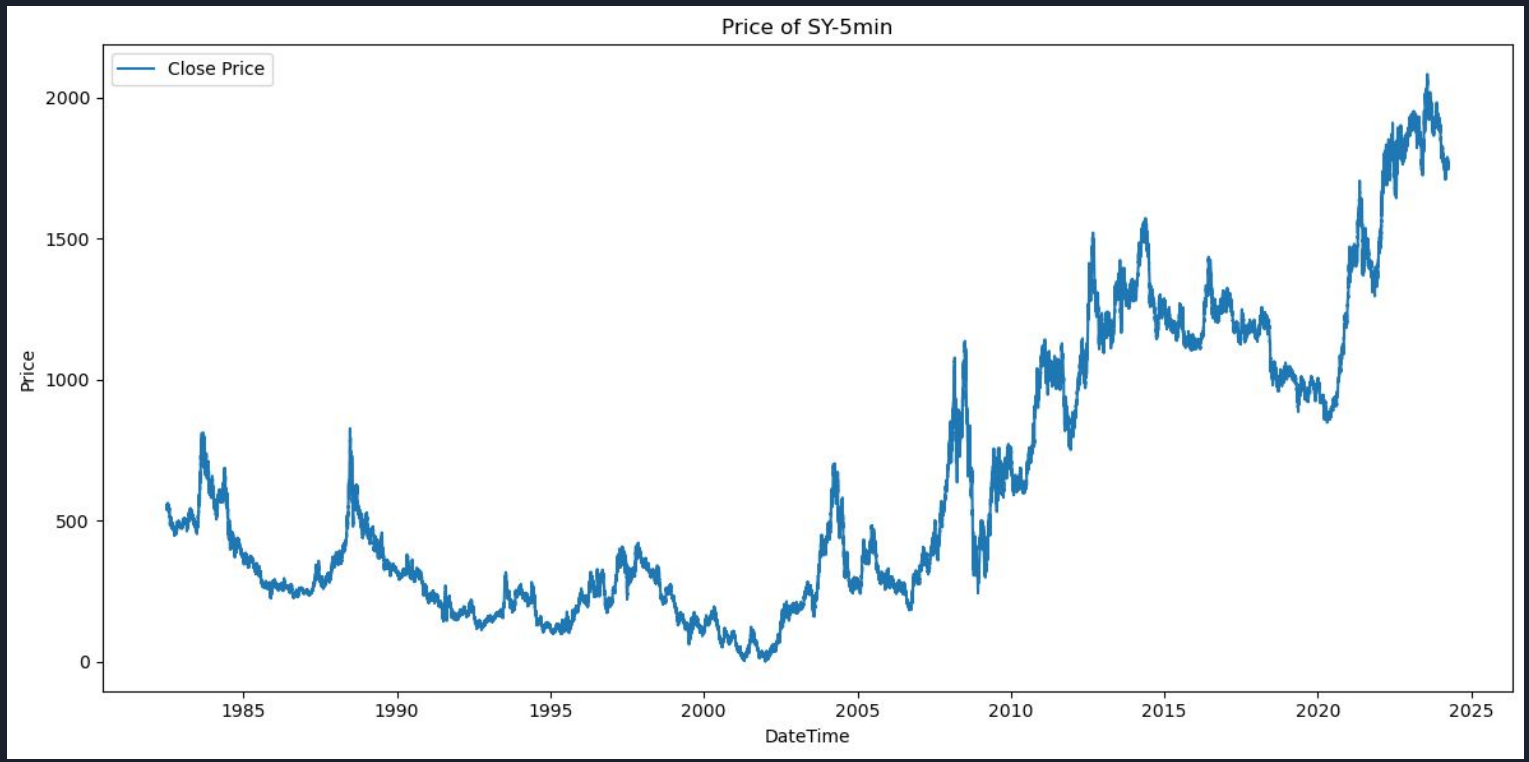
Others

- Transportation cost
- Agricultural policy
- Trade policy

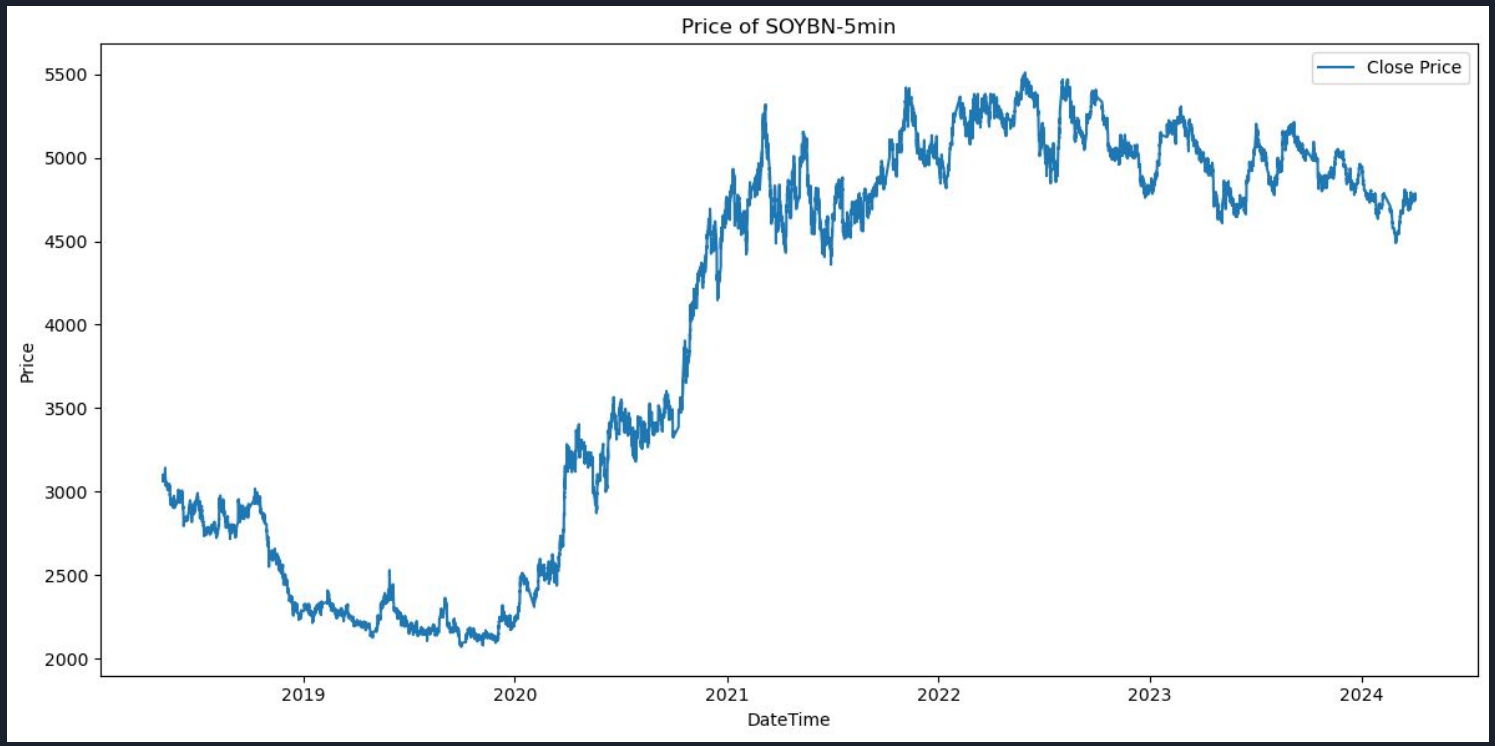
Alternative Products

- Rapeseed, sunflower seeds, cottonseed, sesame, peanut oil.

Historical Price of SY-5min



Historical Price of SOYBN-5min



Statistics for SY and SOYBN

```
SY (5-min interval) Statistics:
Average price change for SY-5min: 0.0025330533865316834
Standard deviation of price for SY-5min: 1.9376428816109892
Average price for SY-5min: 629.181236372709
Max price for SY-5min: (2082.25, Timestamp('2023-07-27 09:35:00'))
Min price for SY-5min: (0.25, Timestamp('2002-01-02 13:05:00'))
Max SY-5min price increase: 86.75
Min SY-5min price decrease: -68.75

------------------------------------------------

SOYBN (5-min interval) Statistics:
Average price change for SOYBN-5min: 0.016398505892459003
Standard deviation of price for SOYBN-5min: 6.186720962883591
Average price for SOYBN-5min: 3978.103978457262
Max price for SOYBN-5min: (5510, Timestamp('2022-05-30 09:10:00'))
Min price for SOYBN-5min: (2071, Timestamp('2019-09-30 11:20:00'))
Max SOYBN-5min price increase: 208.0
Min SOYBN-5min price decrease: -167.0
```

Variance Ratio Test
Introduction

What is Variance Ratio Test?

A very simple test to compare statistical properties of a random time series to those of a random walk.

$$VR(q) = \frac{Var(q)}{q * Var(1)} \qquad VR(q) = 1 + 2 \cdot \sum_{k=1}^{q-1} \left(1 - \frac{k}{q}\right) \cdot \rho_k$$

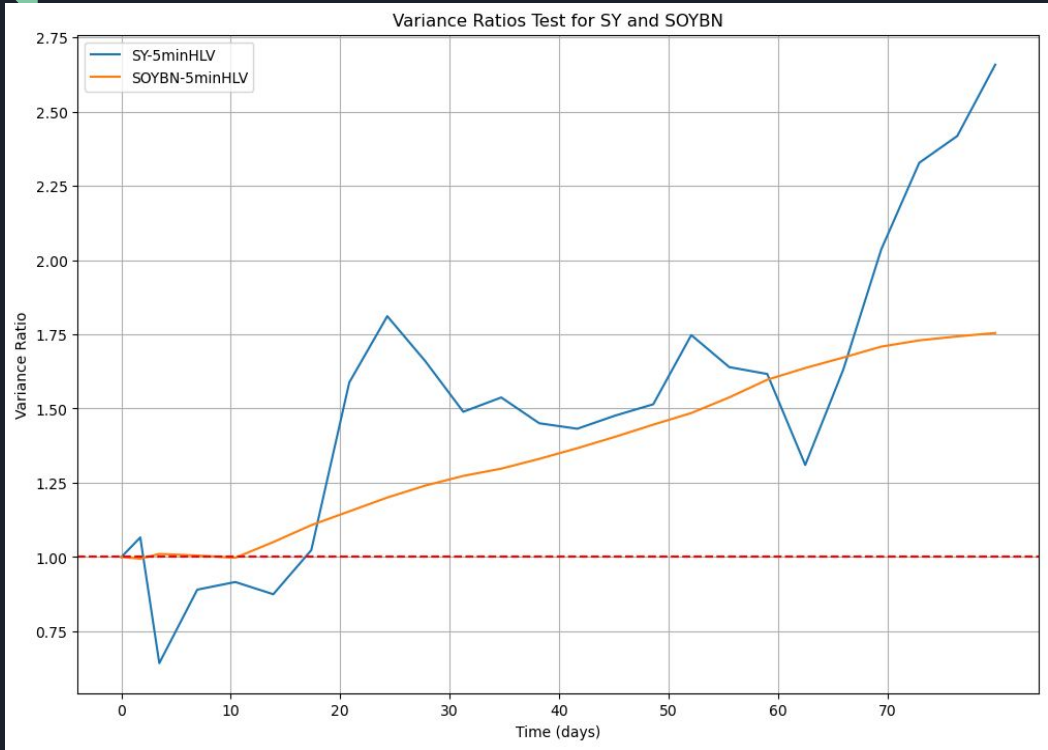
VR(q) = 1, Random Walk, changes in prices or returns are unpredictable

VR(1)>1, Trend-following, price or return series shows some kind of trend, where past upward or downward trends tend to continue rather than move randomly

VR(q)<1, Mean-reverting, prices or returns might deviate from their long-term mean but are inclined to return to this mean over time.

Variance Ratio Test

US Soybean Futures (SY-5min)



From blue line:

*5min data from 07/01/1982 to 04/02/2024

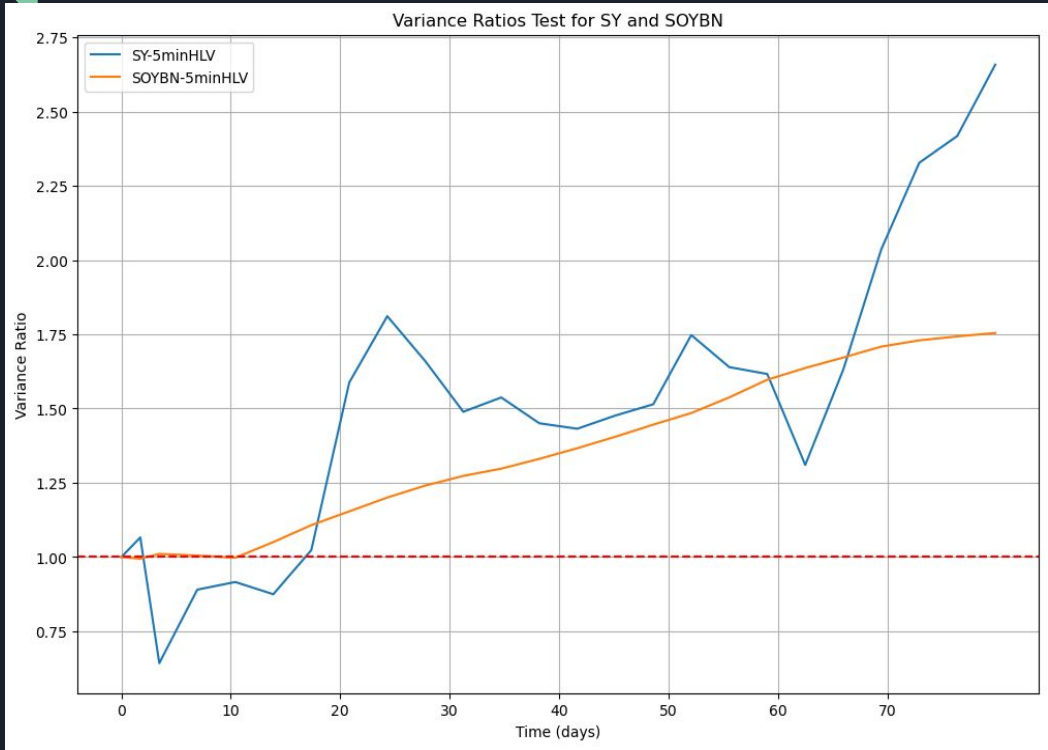
For 'SY-5minHLV', the variance ratio starts below 1, indicating mean-reversion behavior initially which transitions to a trend-following pattern after approximately 20 days.

Short term: VR<1, Mean-reverting

Long term: VR>1, Trend-following

Variance Ratio Test

China Soybean Futures (SOYBN- 5min)



From yellow line:

*5min data from 05/03/2018 to 04/02/2024

For 'SOYBN-5minHLV', the variance ratio starts equal to 1, indicating random walk behavior initially which transitions to a trend-following pattern after approximately 10 days.

Short term: VR=1, Random Walk

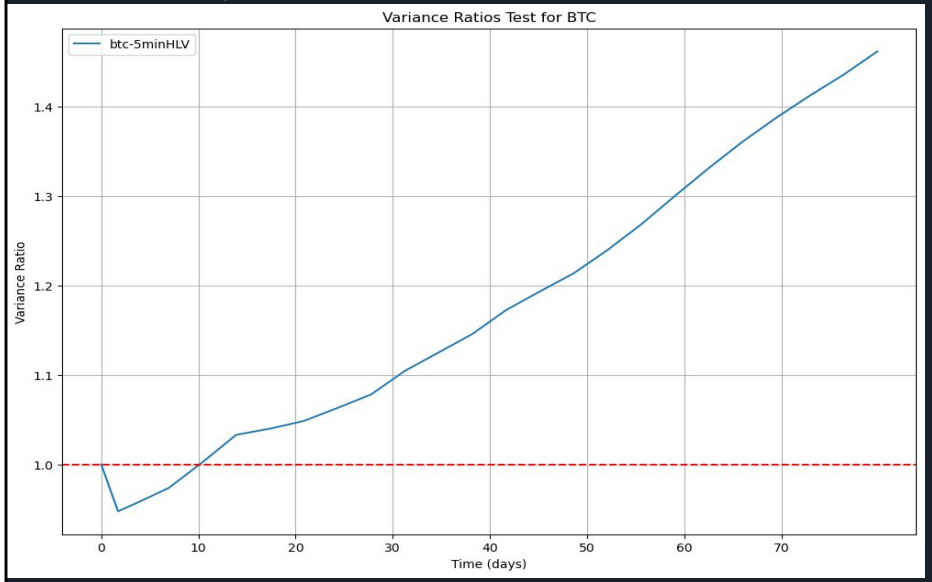
Long term: VR>1, Trend-following

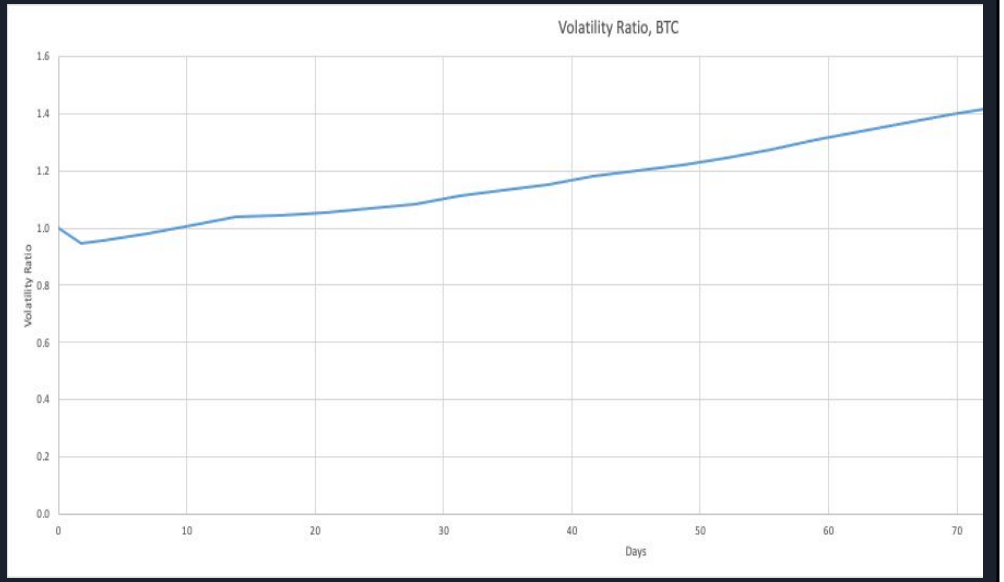
Variance Ratio Test
Data Analysis

LONG TERM: Both SY and SOYBN show trend-following behavior VR>1

Compare the variance ratios between the two time series. It looks like SY generally has a higher variance ratio than SOYBN, which could suggest that SY has stronger trend-following characteristics compared to SOYBN over the same period.

Variance Ratio Test
Apply our Python code to BTC for comparison





Apply our Python code to BTC-5min and compare the result (left) with the result from excel given by professor (right). THEY LOOK PERFECTLY SAME!

Push-Response Test Introduction

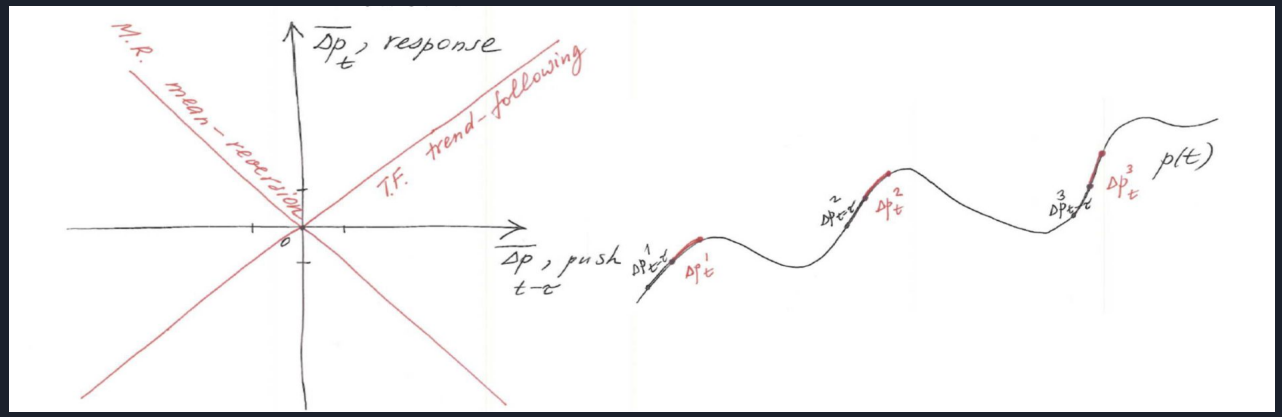
Push-Response function $R = \overline{(\Delta p|_{condition})}$

Given a financial time-series $p(t)$ and a particular choice of time shift $\mathcal{T}$

Where "push" $x = p(t) - p(t-\tau)$

Conditional average "response" $y = \overline{p(t+\tau) - p(t))}|_{p(t)-p(t-\tau)=x}$

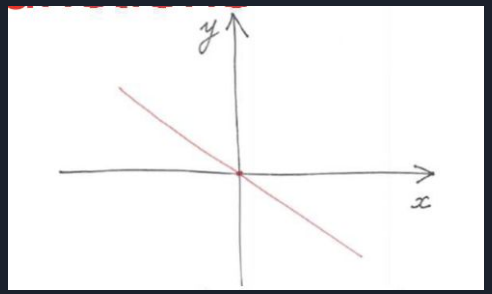
Push-Response Test helps us to investigate price movements within certain time intervals.



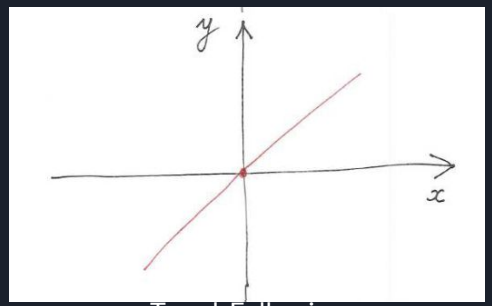
*graph from Professor Alexei, Lecture 2

Push-Response Test Introduction

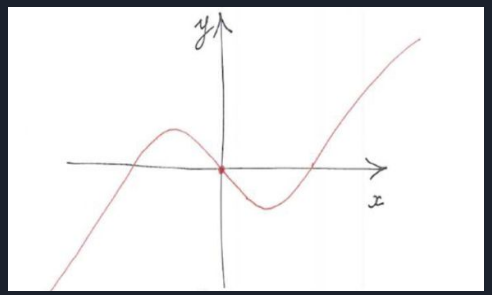
Four Basic Shapes of Push-Response Diagrams:



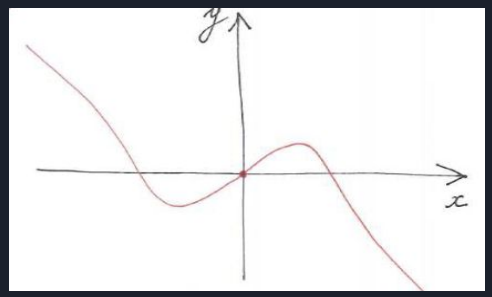
Mean-Reversion



Trend_Following



Short term Mean-Reversion and Long term Trend-Following



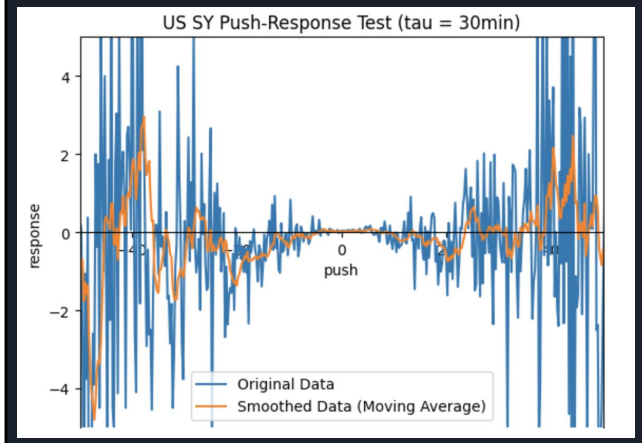
Short term Trend-Following and Long term Mean-Reversion

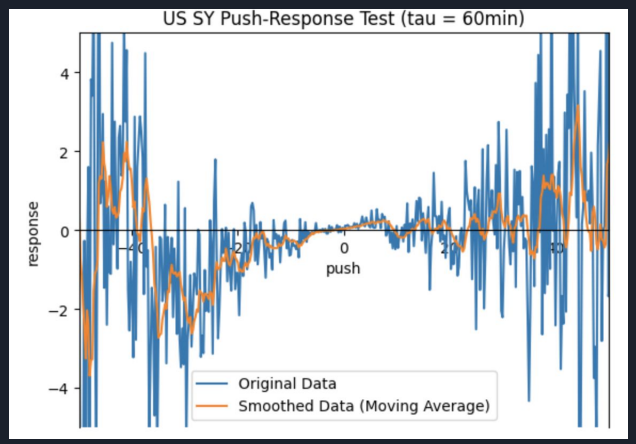
*graph from Professor Alexei, Lecture 2

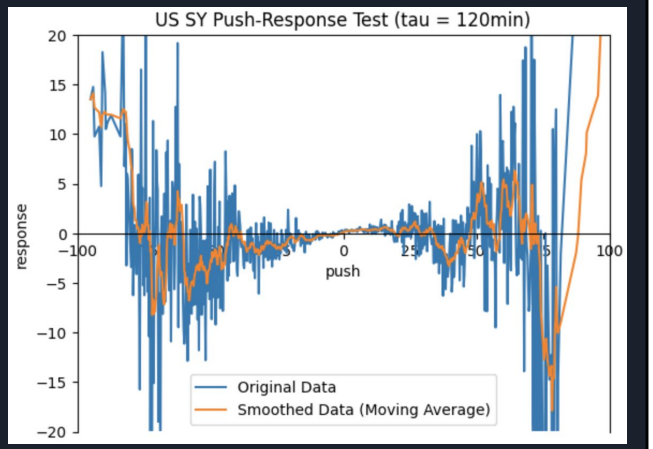
Push-Response Test

US Soybean Futures

*5-min data from 07/01/1982 to 04/02/2024

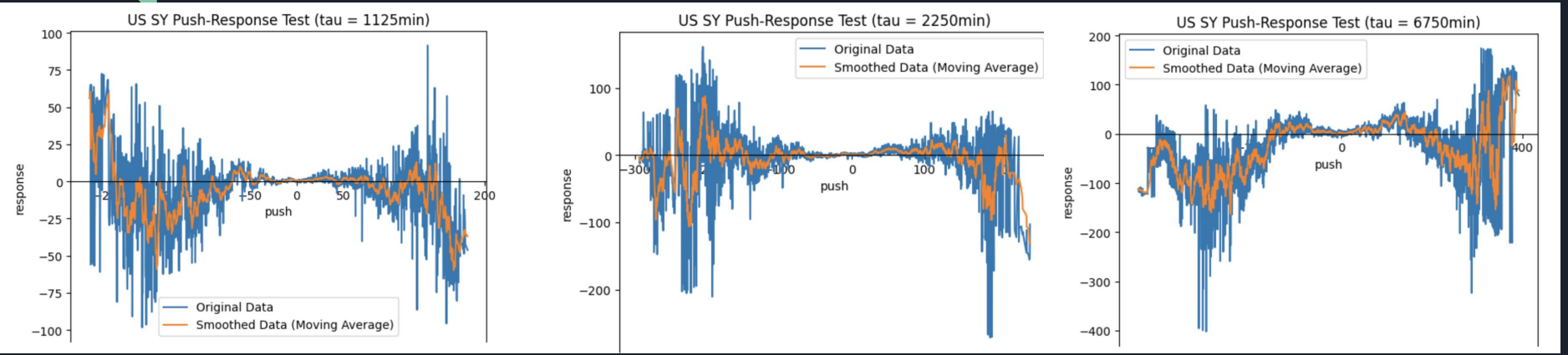






Small push trend-following and large push mean-reversion pattern is obvious for both tau = 30 and 60 minutes when -50 < push < 50. When tau = 120, for larger pushes, it shows a behavior of mean-reversion with push < -50, and a trend-following with push > 50.

With longer time stream...



For tau = 5 days, short push trend-following and large push mean-reversion is shockingly obvious.

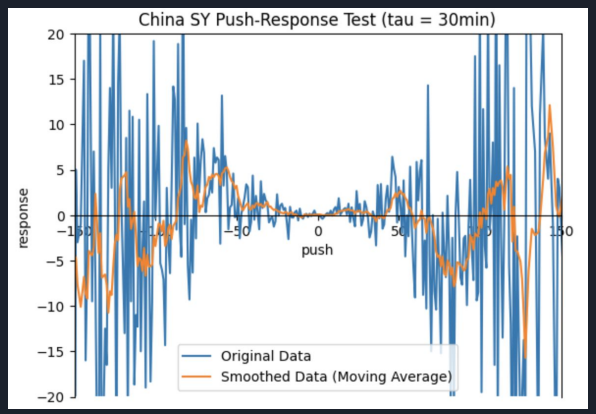
For tau = 10 days, short push trend-following and large push mean-reversion is valid when -200< push<200.

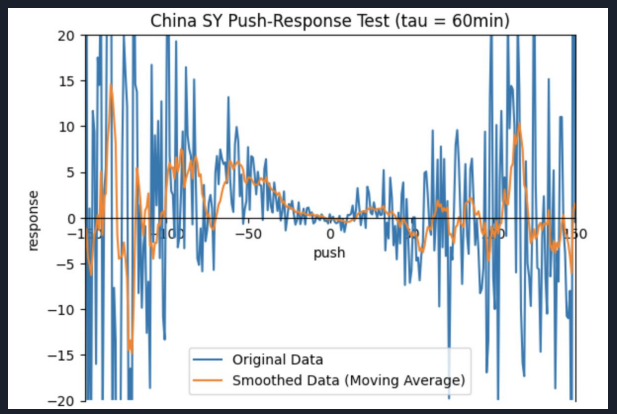
For tau = 30 days, responses behave symmetrically(i.e for negative push, trend-following when large push and mean-reversion when small push.), except when push is around 300, response shows trend-following.

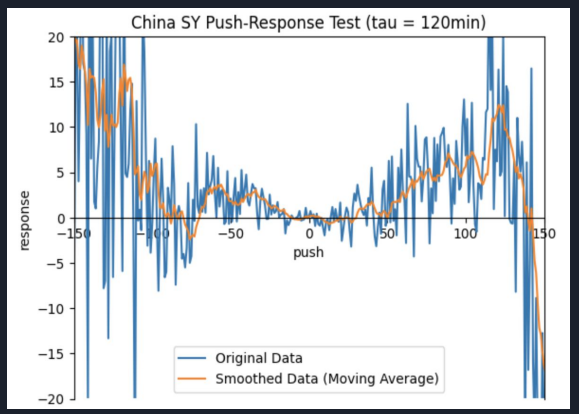
Push-Response Test

China No.1 Soybean Futures

*5-min data from 05/03/2018 to 04/02/2024



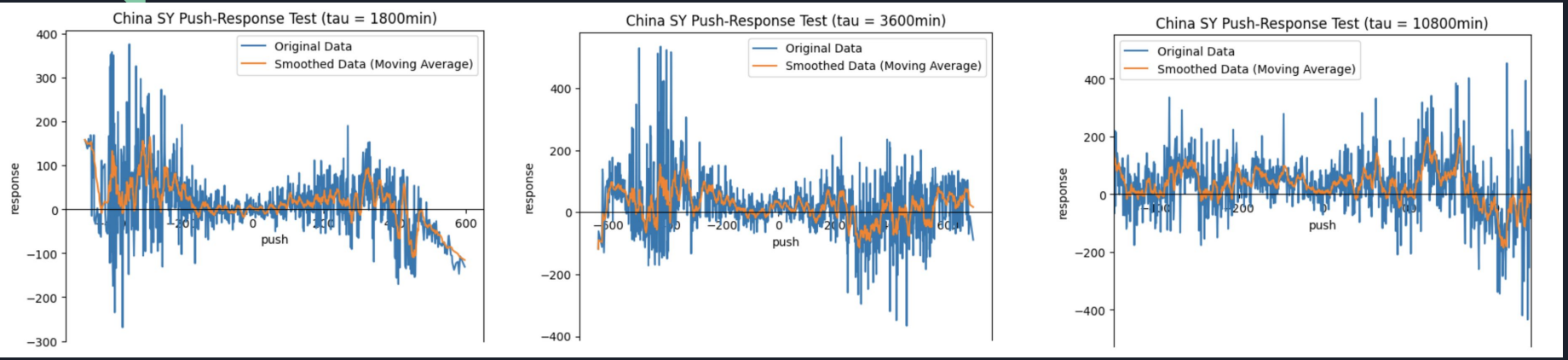




When tau = 30 and 60 minutes, Chinese soybean futures market is more conformed to mean-reversion pattern when push is negative.
When tau = 120 minutes, asymmetric behavior of Chinese Soybean market near 0:
negative push -> positive response: mean-reversion
Positive push -> positive response: trend following

Push-Response Test

China No.1 Soybean Futures



We increase tau to further explore its push-response pattern.
When tau = 5 days, there is mean-reversion with negative large push and trend-following with positive push.
When tau = 10 days, similar to 5 days but shows mean-reversion when large positive push.

The larger tau we use, the less obvious short-term trend following the test shows, but the symmetry becomes more visible: generally mean-reversion on negative pushes and trend-following on positive pushes.

Intro to Strategies

- Strategy: Trend-Following
  - Long 1 futures contract when current price hits Highest High price (HH) in given Channel Length
  - Short 1 futures contract when current price hits Lowest Low price (LL) in given Channel Length
  - Rebalance when price deviates certain percentage (Stop Percentage) from benchmark long/benchmark short (price when enter the position)
- Market and Data:
  - 5-minute Prices, 4 year in-sample data and 3 month out-of-sample data
  - Primary Futures Market: US Soybean Futures (SY)
    - In-Sample Start Date: 05/17/1983
    - Out-of-Sample Start Date: 05/13/1987
  - Secondary Futures Market: NO.1 Soybean Futures (SOYBN)
    - In-Sampe Start Date: 11/22/2018
    - Out-of-Sample Start Date: 01/17/2023
  - We also tried in-sample = 1,2,3,4 years, and out-of-sample = 1,3,6 months (details in later part)
- Parameter Optimization
  - Channel Length: 951 points from 500 to 10000 with step size = 10
  - Stop Percentage: 96 points from 0.005 to 0.10 with step size = 0.001
  - Target Function: Net Profit to Max drawdown Ratio
  - Optimization Methodology: Simplified Random Search (details in the following slide)

Strategies specifics + code

Simplified Random Search

- First use large step size to narrow research range and then use smaller step size to get the best result.
- Step size = 1000: find the parameter i maximizing the target function. Channel Length range shrinks from [500 : 10000] to [i-1000 : i+1000]
- Step size = 100: repeat above process. Find the parameter j. Channel Length range shrinks from [i-1000 : i+1000] to [j-100 : j+100]
- Step size = 10: repeat above process, get the optimal parameter u.

```
// 1000 for channelength
for (int i = 0; i < ChnLen.size(); i += 100){
    Double L = ChnLen.get(i);

    List<Double> HH = new ArrayList<>();
    List<Double> LL = new ArrayList<>();
    //get HH and LL for given length
    for (int k = inSampleStart; k <= inSampleEnd; k += 1){
        HH.add(getMax(dataList.subList(k - L.intValue(), k-1)));
        LL.add(getMin(dataList.subList(k - L.intValue(), k-1)));
    }

    //iterate through each StpPct
    for (int j = 0; j < StpPct.size(); j += 10){
        Double S = StpPct.get(j);
```

```
//100 for chanelength
int u = i_j[0];
int temp = u;

for (u = i_j[0]; u < temp+50; u += 10){
    Double L = ChnLen.get(u);
    List<Double> HH = new ArrayList<>();
    List<Double> LL = new ArrayList<>();
    //get HH and LL for given length
    for (int k = inSampleStart; k <= inSampleEnd; k += 1){
        HH.add(getMax(dataList.subList(k - L.intValue(), k-1)));
        LL.add(getMin(dataList.subList(k - L.intValue(), k-1)));
    }

    //iterate through each StpPct
    for (int j = 0; j < StpPct.size(); j += 10){
        Double S = StpPct.get(j);
```

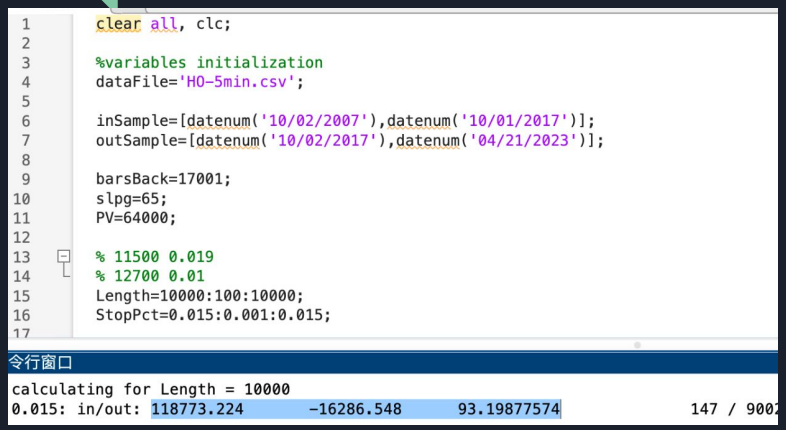
```
//10 for chanelength
int y = i_j[0];
temp = y;
for (y = i_j[0]; y < temp+5; y += 1){
    Double L = ChnLen.get(y);
    List<Double> HH = new ArrayList<>();
    List<Double> LL = new ArrayList<>();
    //get HH and LL for given length
    for (int k = inSampleStart; k <= inSampleEnd; k += 1){
        HH.add(getMax(dataList.subList(k - L.intValue(), k-1)));
        LL.add(getMin(dataList.subList(k - L.intValue(), k-1)));
    }

    //iterate through each StpPct
    for (int j = 0; j < StpPct.size(); j += 1){
        Double S = StpPct.get(j);
```

General rubrics:

1. For each in sample period, find the optimal parameter Channel Length and Stop Percentage that maximize the in sample target function, then use these optimal parameters on the out sample period. Record target function output, net profits, equity, etc.
2. Push the insample period forward by the length of an out sample period, repeat the process above, find the next optimal parameter and run it on the following out sample period.
3. Concatenate all output data into output table and transform it into CSV file.
4. Slippage = 65(5 bp estimation), PV = 50(in dollar), E0 = 200000 (National currency)

Sanity check: using HO-5min.csv



```
clear all, clc;

%variables initialization
dataFile='HO-5min.csv';

inSample=[datenum('10/02/2007'),datenum('10/01/2017')];
outSample=[datenum('10/02/2017'),datenum('04/21/2023')];

barsBack=17001;
slpg=65;
PV=64000;

% 11500 0.019
% 12700 0.01
Length=10000:100:10000;
StopPct=0.015:0.001:0.015;
```

```
令行窗口
calculating for Length = 10000
0.015: in/out: 118773.224        -16286.548       93.19877574              147 / 900
```

```
    System.out.println(totalLength);
    //int inSampleStart = Math.min(barsBack + 1 + 4*252*44, totalLength-1);
    //int inSampleEnd = Math.min(inSampleStart + 4*252*44, totalLength-1); //number of 5-min data in 4 ye
    int inSampleStart = Math.min(a:349794, totalLength-1);
    //System.out.println("insamplestart"+inSampleStart);
    int inSampleEnd = Math.min(349794 + 10*252*54, totalLength-1);
    int outSampleStart = Math.min(inSampleEnd + 1, totalLength-1);
    int outSampleEnd = Math.min(outSampleStart + 3*22*44, totalLength-1); //number of 5-min data in 3 qua

    List<data_i> inSampleData = dataList.subList(inSampleStart, inSampleEnd);
    List<data_i> outSampleData = dataList.subList(outSampleStart, outSampleEnd);
```

```
PROBLEMS 13  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS

volume =0.0'}
613157
calculating length = 10000.0
calculating PctStp = 0.015
netProfift109224.32000000041
dd_max-16282.048000000097
netProfit_ddMax_ratio: 6.708266675052165
6.708266675052165
[10000.0, 0.015]
lch@Chuhes-MBP project2 %
```

Channel Length = 10000;

StopPct = 0.015;

Note we use a different slippage which leads to slightly different net profits.

Backtesting

- Optimal parameters found from in-sample data was then be applied to out-of-sample data
- Slippage = 65, PV = 50, E0 = 200000 in domestic currency
- Trade-by-Trade table was generated to record each trade in out-of-sample period
- Statistics
  - Full Out-of-Sample Statistics
    - Average Rate of Return
    - Standard Deviation of Returns
    - Sharpe Ratio
    - % of Winners
    - Returns on the Account
    - Average Winner
    - Average Loser
    - Profit Factor
  - Each Out-of-Sample Statistics
    - Average Return
    - Deviation
    - Sharpe Ratio
    - % of Winners
    - Max Drawdown
    - Net Profit to Max Drawdown

```
def ror(nav_lst):
    time_length = (nav_lst.shape[0]-1)*5/60/24
    return (nav_lst.iloc[-1,0] / nav_lst.iloc[0,0] - 1) * 252 / time_length

def vol(rtn_lst):
    return np.std(rtn_lst[0], ddof = 1) * (252 * 24 * 60 / 5)**0.5

def sharpe(nav_lst, rtn_lst):
    return ror(nav_lst) / vol(rtn_lst)

def num_trades(trades_lst):
    return trades_lst.shape[0]

def pct_winner(trades_lst):
    return trades_lst[trades_lst['Absolute_PnL']>0].shape[0] / num_trades(trades_lst)

def pct_profitable(trades_lst):
    return trades_lst[trades_lst['Absolute_PnL']>65].shape[0] / num_trades(trades_lst)

def mdd_scale(return_list):
    l = np.argmax((np.maximum.accumulate(return_list) - return_list) /np.maximum.accumulate(return_list))
    k = np.argmax(return_list[:l])
    return (return_list[k] - return_list[l])

def rtn_on_acct(nav_lst, oss):
    return np.nansum(oss['netProfit']) / abs(mdd_scale(np.array(nav_lst[0])))

def avg_winner(trades_lst):
    return np.nanmean(trades_lst[trades_lst['Absolute_PnL']>0]['Absolute_PnL'])
def avg_loser(trades_lst):
    return abs(np.nanmean(trades_lst[trades_lst['Absolute_PnL']<0]['Absolute_PnL']))

def profit_factor(trades_lst):
    return np.nansum(trades_lst[trades_lst['Absolute_PnL']>0]['Absolute_PnL']) / abs(np.nansum(trades_lst[trades_lst['Absolute_P
```

More Optimal Parameter Table for 4Y3M

US Soybeans

Out-of-Sample Start Date	Out-of-Sample End Date	Channel Length	Stop Percentage
05/13/1987 09:35	08/14/1987 13:15	7500.00	0.0400
08/17/1987 09:35	11/17/1987 13:15	520.00	0.0450
11/18/1987 09:35	02/23/1988 13:15	530.00	0.0590
02/24/1988 09:35	05/26/1988 13:15	530.00	0.0540
05/27/1988 09:35	08/30/1988 13:15	530.00	0.0540
08/31/1988 09:35	12/02/1988 13:15	500.00	0.0540
12/05/1988 09:35	03/09/1989 13:15	500.00	0.0540
03/10/1989 09:35	06/13/1989 13:15	500.00	0.0540
06/14/1989 09:35	09/15/1989 13:15	500.00	0.0540
09/18/1989 09:35	12/19/1989 13:15	9500.00	0.0150
12/20/1989 09:35	03/26/1990 13:15	9500.00	0.0150
03/27/1990 09:35	06/28/1990 13:15	9500.00	0.0150
06/29/1990 09:35	10/02/1990 13:15	9500.00	0.0150
10/03/1990 09:35	01/07/1991 13:15	9500.00	0.0150
01/08/1991 09:35	04/11/1991 13:15	9500.00	0.0150
04/12/1991 09:35	07/16/1991 13:15	9500.00	0.0150
07/17/1991 09:35	10/17/1991 13:15	9500.00	0.0150
10/18/1991 09:35	01/22/1992 13:15	9500.00	0.0150
01/23/1992 09:35	04/27/1992 13:15	2500.00	0.0450
04/28/1992 09:35	07/30/1992 13:15	2500.00	0.0450
07/31/1992 09:35	11/02/1992 13:15	9500.00	0.0200
11/03/1992 09:35	02/05/1993 13:15	4540.00	0.0200
02/08/1993 09:35	05/12/1993 13:15	4540.00	0.0200
05/13/1993 09:35	08/16/1993 13:15	9800.00	0.0200
08/17/1987 09:35	11/17/1987 13:15	520.00	0.0450
11/18/1987 09:35	02/23/1988 13:15	530.00	0.0590
02/24/1988 09:35	05/26/1988 13:15	530.00	0.0540
05/27/1988 09:35	08/30/1988 13:15	530.00	0.0540
08/31/1988 09:35	12/02/1988 13:15	500.00	0.0540
12/05/1988 09:35	03/09/1989 13:15	500.00	0.0540
03/10/1989 09:35	06/13/1989 13:15	500.00	0.0540
06/14/1989 09:35	09/15/1989 13:15	500.00	0.0540
09/18/1989 09:35	12/19/1989 13:15	9500.00	0.0150
12/20/1989 09:35	03/26/1990 13:15	9500.00	0.0150
03/27/1990 09:35	06/28/1990 13:15	9500.00	0.0150
06/29/1990 09:35	10/02/1990 13:15	9500.00	0.0150
10/03/1990 09:35	01/07/1991 13:15	9500.00	0.0150
01/08/1991 09:35	04/11/1991 13:15	9500.00	0.0150
04/12/1991 09:35	07/16/1991 13:15	9500.00	0.0150
07/17/1991 09:35	10/17/1991 13:15	9500.00	0.0150
10/18/1991 09:35	01/22/1992 13:15	9500.00	0.0150
01/23/1992 09:35	04/27/1992 13:15	2500.00	0.0450
04/28/1992 09:35	07/30/1992 13:15	2500.00	0.0450
07/31/1992 09:35	11/02/1992 13:15	9500.00	0.0200
11/03/1992 09:35	02/05/1993 13:15	4540.00	0.0200
02/08/1993 09:35	05/12/1993 13:15	4540.00	0.0200
05/13/1993 09:35	08/16/1993 13:15	9800.00	0.0200

Part of 3 month Out-of-Sample Optimal Parameters Table

Optimal Parameter Table for 4Y3M

No.1 Soybean Futures

Out-of-Sample Start Date	Out-of-Sample End Date	Channel Length	Stop Percentage
01/17/2023 09:05	04/26/2023 15:00	630.00	0.0060
04/27/2023 09:05	08/03/2023 15:00	630.00	0.0060
08/04/2023 09:05	11/13/2023 15:00	630.00	0.0060
11/14/2023 09:05	02/22/2024 15:00	630.00	0.0060

3 month Out-of-Sample Optimal Parameters Table

Trade-by-Trade Table for 4Y3M

US Soybeans

Date_In	Time_In	Date_Out	Time_Out	Position_Before_Exit	Price_In	Price_Out	Absolute_PnL
05/14/1987	10:35	05/14/1987	12:05	1	341.75	331.92	-555.50
06/15/1987	09:35	06/17/1987	09:35	1	345.75	342.96	-203.50
08/19/1987	11:25	09/23/1987	09:35	1	273.25	290.56	801.44
10/01/1987	09:35	10/12/1987	09:50	1	304.25	300.59	-247.19
10/19/1987	09:35	10/19/1987	13:00	1	314.75	300.25	190.50
10/19/1987	13:00	10/19/1987	13:00	-1	300.25	292.60	-662.00
10/19/1987	13:05	10/19/1987	13:10	-1	300.25	293.91	253.19
11/09/1987	09:35	11/17/1987	11:00	1	309.75	322.07	552.19
11/20/1987	09:35	12/03/1987	10:30	1	337.25	349.82	564.34
12/16/1987	11:45	12/21/1987	09:35	-1	335.75	352.38	-895.61
12/21/1987	13:00	12/29/1987	10:05	1	358.00	347.93	-567.26
01/04/1988	10:15	01/12/1988	12:50	1	369.75	362.52	-425.49
01/15/1988	09:35	01/27/1988	09:35	1	385.25	366.28	-1012.29
01/28/1988	12:40	02/11/1988	09:35	-1	360.25	362.44	-173.64
02/12/1988	13:00	02/23/1988	09:35	1	370.75	370.99	-52.04
03/04/1988	09:55	03/17/1988	09:50	-1	362.25	364.95	-198.87
03/21/1988	09:40	04/15/1988	10:50	1	375.25	397.56	1051.32
04/21/1988	12:00	04/26/1988	13:10	-1	394.25	412.38	-970.37
04/29/1988	10:00	05/20/1988	10:10	1	417.00	493.81	3776.60
05/31/1988	09:35	06/07/1988	09:50	1	522.00	601.89	3930.62
06/10/1988	11:05	06/10/1988	12:50	1	636.25	606.62	-1545.38
06/15/1988	09:35	06/23/1988	11:55	1	641.25	782.11	6978.78
07/06/1988	10:55	07/06/1988	12:35	-1	670.25	705.39	-1820.98
07/08/1988	09:35	07/13/1988	09:35	-1	669.25	638.99	1449.12
07/20/1988	09:35	07/22/1988	09:35	-1	606.25	586.29	934.12
07/25/1988	09:35	07/29/1988	11:50	-1	556.25	504.60	2518.37
08/04/1988	13:10	08/08/1988	09:35	1	602.25	585.34	-909.63
08/16/1988	09:45	08/17/1988	09:35	1	618.75	591.01	-1450.82
08/22/1988	09:35	08/24/1988	12:50	-1	574.75	562.57	544.88
09/06/1988	10:55	09/13/1988	09:35	1	615.75	593.85	-1158.93
09/16/1988	13:15	10/04/1988	10:50	-1	583.25	548.87	1654.98
10/07/1988	12:35	10/31/1988	10:25	-1	520.75	501.44	901.47
11/11/1988	11:25	11/22/1988	12:55	-1	476.75	460.33	756.77
12/02/1988	11:10	12/02/1988	13:15	1	473.25	476.75	143.00
12/05/1988	09:35	01/16/1989	09:35	1	477.75	497.75	1103.00
01/16/1989	09:35	01/24/1989	11:20	-1	497.75	462.97	1507.02
01/26/1989	10:05	01/26/1989	12:55	-1	439.25	459.28	-1065.53
02/10/1989	10:40	02/17/1989	13:00	-1	435.75	439.78	-265.57
02/22/1989	12:10	03/09/1989	13:15	1	454.75	462.75	368.00
03/10/1989	10:55	03/27/1989	13:15	1	470.75	454.79	-862.03
03/28/1989	10:10	04/12/1989	09:35	-1	452.75	411.85	1980.97
04/17/1989	09:50	04/24/1989	12:55	1	429.25	419.79	-537.13
04/28/1989	09:35	05/03/1989	10:05	-1	408.50	422.39	-758.53
05/16/1989	10:00	05/26/1989	09:35	-1	405.75	384.18	1014.35

Part of 3 month Out-of-Sample Trade-by-Trade Table

Trade-by-Trade Table for 4Y3M

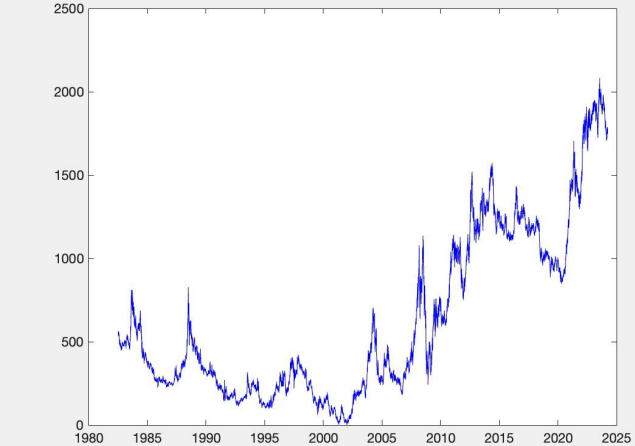
No.1 Soybean Futures

Date_In	Time_In	Date_Out	Time_Out	Position_Before_Exit	Price_In	Price_Out	Absolute_PnL
01/17/2023	09:05	01/19/2023	09:05	1	4985.00	5089.28	5150.00
01/19/2023	09:30	01/19/2023	10:55	1	5120.00	5125.06	189.20
01/30/2023	09:40	01/30/2023	11:10	1	5156.00	5172.78	774.80
02/02/2023	09:05	02/02/2023	09:40	1	5204.00	5196.63	-432.40
02/14/2023	09:05	02/14/2023	10:35	-1	5131.00	5109.47	1012.30
02/17/2023	11:00	02/20/2023	09:10	1	5226.00	5213.53	-687.50
02/20/2023	11:35	02/21/2023	09:05	1	5245.00	5214.52	-1587.80
02/22/2023	09:05	02/23/2023	10:45	1	5246.00	5279.13	1592.70
03/01/2023	09:05	03/01/2023	10:00	-1	5202.00	5202.03	-65.30
03/03/2023	09:05	03/03/2023	11:15	-1	5171.00	5159.77	497.30
03/07/2023	09:05	03/09/2023	09:05	-1	5129.00	5063.20	3226.10
03/21/2023	09:20	03/21/2023	09:35	-1	5033.00	5061.19	-1473.30
03/22/2023	13:55	03/22/2023	14:25	-1	5031.00	5051.13	-1070.30
03/27/2023	09:45	03/27/2023	10:45	-1	5021.00	5011.89	391.40
03/30/2023	09:05	03/30/2023	09:20	-1	4982.00	5006.86	-1307.10
03/30/2023	09:55	03/30/2023	11:05	-1	4977.00	4999.82	-1205.00
04/06/2023	09:05	04/06/2023	09:15	-1	4970.00	4986.74	-901.10
04/06/2023	09:50	04/07/2023	09:05	-1	4957.00	4943.48	611.80
04/11/2023	09:55	04/12/2023	14:15	-1	4914.00	4921.35	-431.60
04/17/2023	11:10	04/18/2023	09:45	-1	4892.00	4917.33	-1330.40
04/20/2023	09:05	04/24/2023	09:05	-1	4888.00	4733.23	7674.50
04/27/2023	11:30	04/28/2023	09:55	-1	4705.00	4654.76	2447.90
05/04/2023	09:25	05/04/2023	09:40	-1	4627.00	4640.68	-747.90
05/05/2023	09:30	05/05/2023	10:05	-1	4613.00	4631.62	-995.20
05/08/2023	10:00	05/09/2023	09:05	1	4822.00	4835.81	626.50
05/16/2023	11:10	05/16/2023	11:15	1	4865.00	4835.81	-1523.50
05/25/2023	10:00	05/26/2023	13:35	-1	4707.00	4681.92	1189.80
05/29/2023	14:00	05/30/2023	09:05	-1	4654.00	4671.86	-957.20
06/05/2023	09:50	06/05/2023	11:30	1	4755.00	4748.34	-397.10
06/15/2023	09:05	06/15/2023	10:45	-1	4670.00	4686.95	-911.70
06/16/2023	09:20	06/19/2023	09:10	1	4769.00	4888.49	5910.60
06/20/2023	13:55	06/20/2023	14:25	1	4918.00	4895.45	-1191.50
06/20/2023	14:55	06/26/2023	09:05	1	4925.00	4948.13	1092.60
06/26/2023	14:45	06/27/2023	09:05	1	4978.00	4950.12	-1458.00
06/27/2023	14:00	06/27/2023	14:50	1	4980.00	4953.10	-1408.90
06/28/2023	10:50	06/30/2023	09:05	1	4983.00	5025.66	2069.20
07/03/2023	09:05	07/03/2023	09:20	1	5056.00	5185.70	6420.90
07/13/2023	09:05	07/13/2023	09:10	-1	5019.00	4994.79	1146.50
07/20/2023	09:10	07/20/2023	10:35	-1	4965.00	4992.78	-1452.90
07/21/2023	09:05	07/25/2023	09:15	-1	4963.00	4862.00	4986.10
07/31/2023	09:05	07/31/2023	13:50	-1	4833.00	4823.77	397.50
08/03/2023	09:05	08/03/2023	09:45	-1	4795.00	4801.64	-395.90
08/07/2023	10:05	08/07/2023	13:35	1	4892.00	4872.59	-1034.60
08/09/2023	09:05	08/09/2023	10:10	1	4902.00	4943.16	1994.10
08/09/2023	11:10	08/10/2023	09:05	1	4973.00	4971.99	-114.60
08/17/2023	09:10	08/18/2023	09:25	1	5002.00	5125.06	6089.20
08/18/2023	10:15	08/18/2023	13:35	1	5156.00	5136.00	-1064.10
08/28/2023	09:05	08/28/2023	13:45	1	5167.00	5150.91	-868.60
08/29/2023	09:05	08/29/2023	10:35	1	5182.00	5161.84	-1071.90

Part of 3 month Out-of-Sample Trade-by-Trade Table

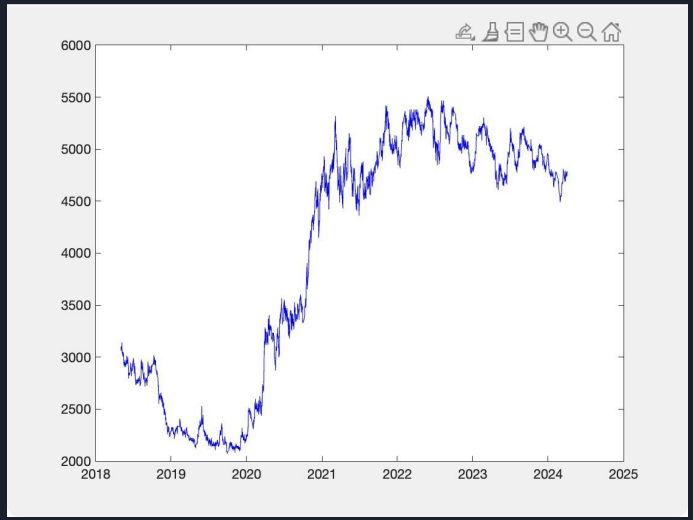
Results

SY



x-axis: Date
y-axis: Closing price
Blue line: Closing price from 1980 to 2024

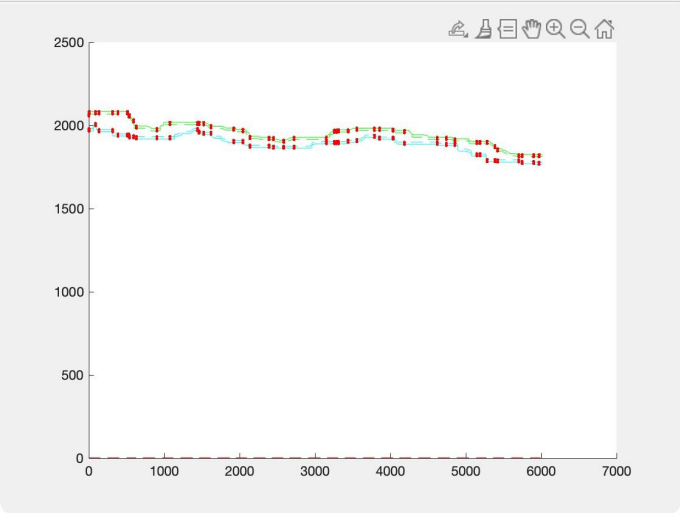
SOYBN



x-axis: Date
y-axis: Closing price
Blue line: Closing price from 2018 to 2024

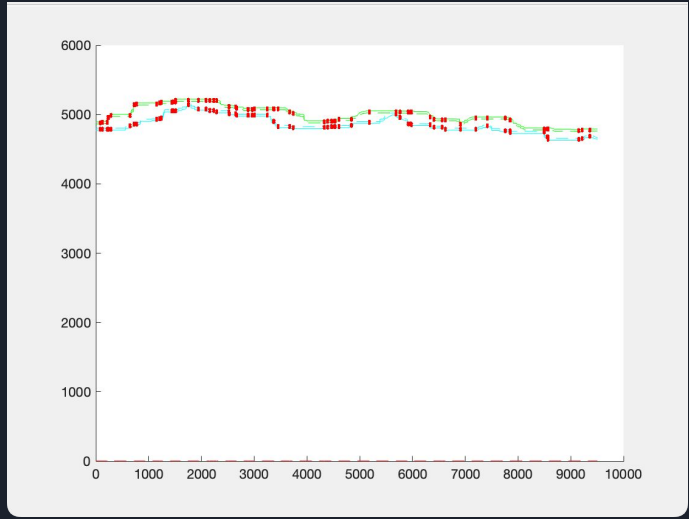
Results

SY-4Y3M



x-axis: Date
y-axis: Closing price
OutSample: 07/27/2023, 02/06/2024
Length: 510
StopPct: 0.007

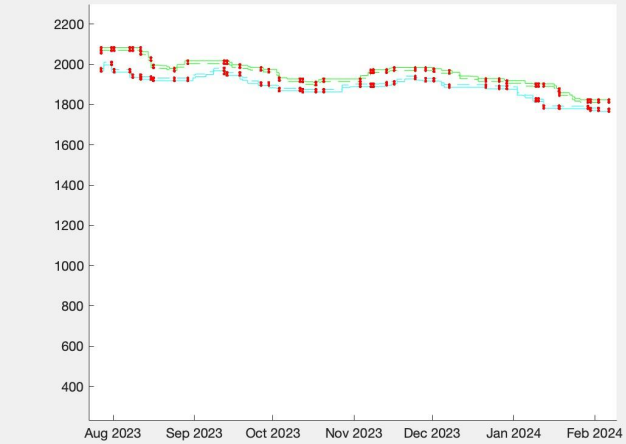
SOYBN-4Y3M



x-axis: Date
y-axis: Closing price
OutSample: 08/04/2023
Length: 630
StopPct: 0.006

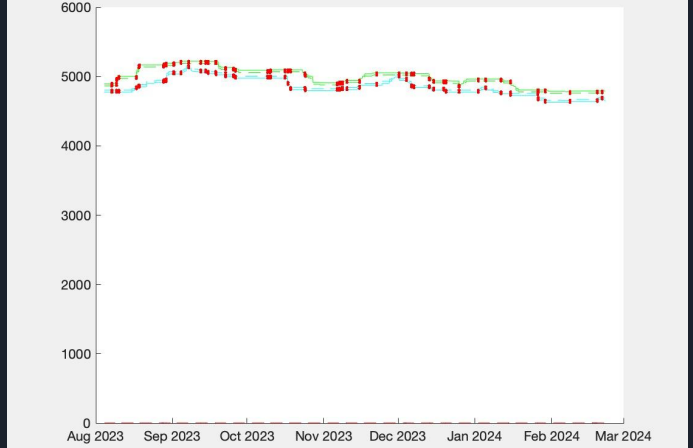
Results

SY-4Y3M



Green: Highest Historical Highs (HH)
Green dash: Adjusted Highs
Blue: Lowest Historical Lows (LL)
Blue dash: Adjusted Lows
Red dot: Trading points

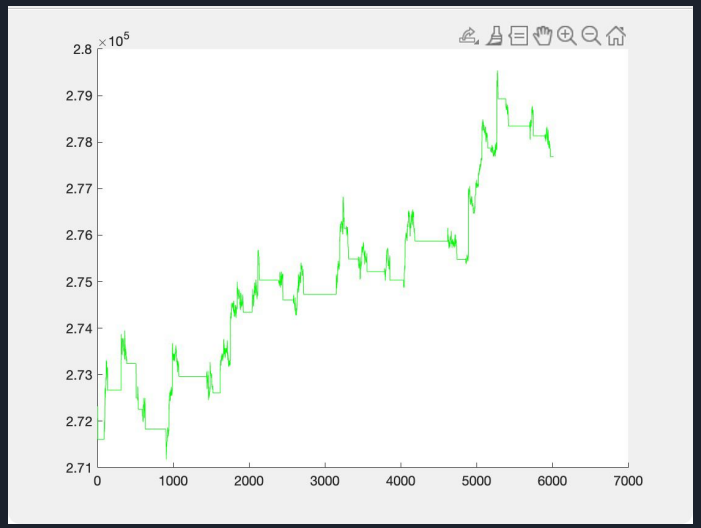
SOYBN-4Y3M



Green: Highest Historical Highs (HH)
Green dash: Adjusted Highs
Blue: Lowest Historical Lows (LL)
Blue dash: Adjusted Lows
Red dot: Trading points

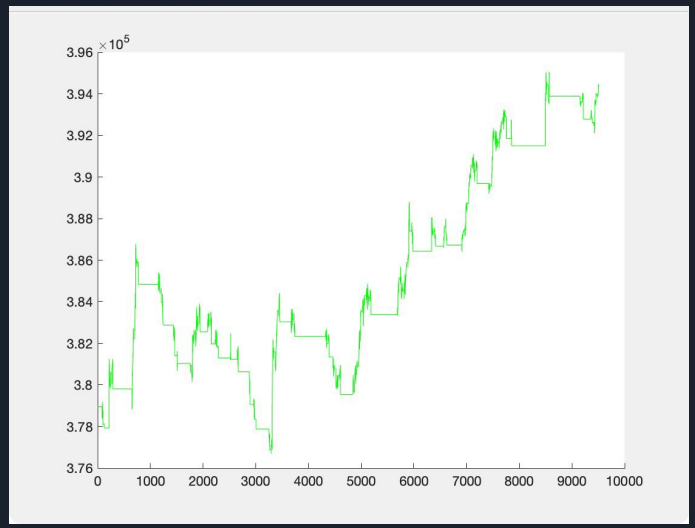
Results

SY-4Y3M



Green: Equity Values

SOYBN-4Y3M



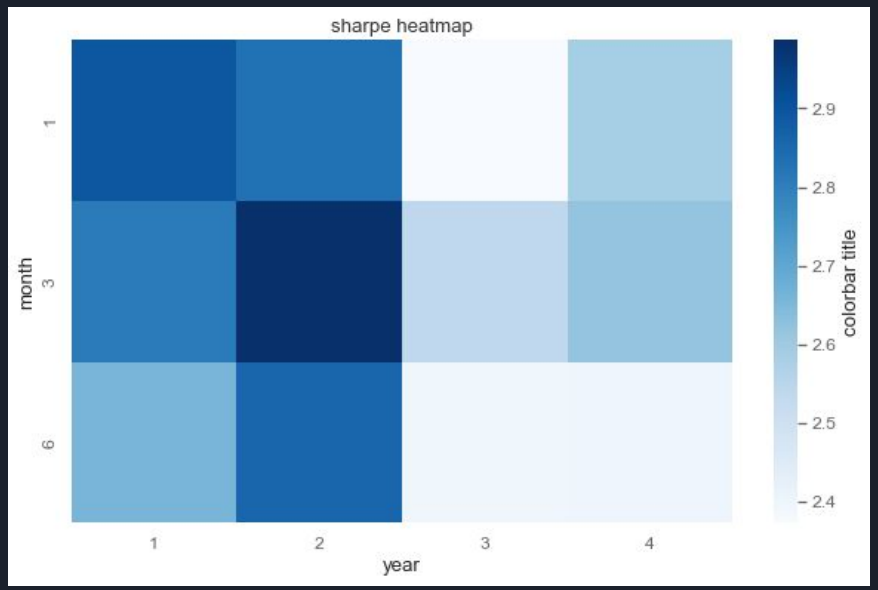
Green: Equity Values

Output Statistics

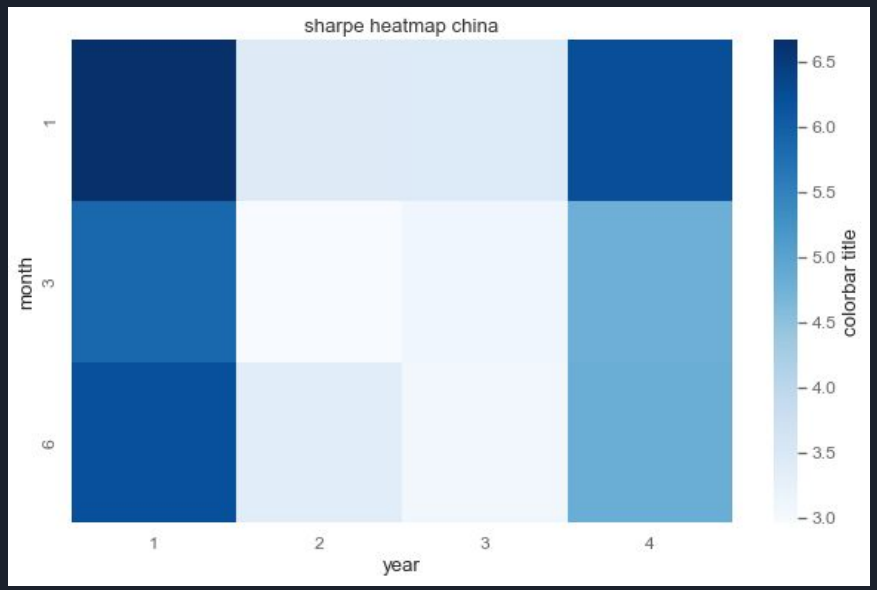
	1Y1M	1Y3M	1Y6M	2Y1M	2Y3M	2Y6M	3Y1M	3Y3M	3Y6M	4Y1M	4Y3M	4Y6M
ror	0.125836	0.124536	0.117915	0.13151	0.13612	0.130545	0.113024	0.123324	0.116659	0.1189	0.123559	0.115313
vol	0.043467	0.044292	0.044322	0.04641	0.045566	0.045658	0.047635	0.048584	0.048668	0.045951	0.047199	0.048042
sharpe	2.894981	2.811678	2.660434	2.83366	2.987311	2.859218	2.372722	2.538399	2.397049	2.587547	2.617835	2.400253
# trades	1435	1451	1435	1426	1383	1398	1164	1099	1095	1051	1067	1013
% winner	0.403484	0.396278	0.390941	0.396213	0.402025	0.404864	0.405498	0.414013	0.415525	0.4196	0.426429	0.424482
% profitable	0.351916	0.33632	0.333101	0.33871	0.342733	0.346924	0.367698	0.372157	0.369863	0.382493	0.388941	0.385982
rtn_on_acct	16.01624	14.34824	13.86699	12.78826	15.50182	21.7284	9.311763	10.90454	8.661261	8.64227	8.286925	7.545999
avg_winner	630.0037	633.2217	633.0648	658.2572	650.6997	631.2497	700.2781	727.4959	709.051	735.8792	732.0494	740.9912
avg_loser	243.2556	238.7834	238.5092	246.9406	238.0959	239.3707	284.705	288.2984	289.2624	308.1285	312.9156	319.8915
profit_factor	1.751802	1.740666	1.703705	1.749236	1.837375	1.794003	1.677688	1.782846	1.742677	1.726567	1.739294	1.708482

1Y1M china	1Y3M china	1Y6M china	2Y1M china	2Y3M china	2Y6M china	3Y1M china	3Y3M china	3Y6M china	4Y1M china	4Y3M china	4Y6M china
0.78975	0.7119	0.804494	0.440709	0.372616	0.427575	0.433076	0.368433	0.378408	0.946092	0.677121	0.743536
0.118427	0.121009	0.129571	0.128319	0.125778	0.126454	0.125761	0.118738	0.122919	0.151423	0.141173	0.153976
6.668667	5.883043	6.208885	3.434474	2.962497	3.381264	3.44363	3.102902	3.078522	6.248001	4.796405	4.828914
387	371	391	217	201	209	103	85	93	81	77	77
0.483204	0.471698	0.470588	0.437788	0.422886	0.416268	0.417476	0.411765	0.419355	0.469136	0.454545	0.454545
0.457364	0.444744	0.445013	0.414747	0.402985	0.401914	0.407767	0.4	0.408602	0.45679	0.441558	0.441558
8.396851	6.524793	8.633762	3.67054	2.699474	3.933161	4.505775	3.833226	3.93701	5.548068	4.071666	4.071666
1609.783	1567.993	1623.253	1725.347	1760.426	1886.44	2273.313	2372.71	2225.695	2493.587	2270.946	2270.946
695.038	686.548	730.387	775.8602	785.2009	794.5168	873.0633	888.962	873.3398	904.4837	916.3214	916.3214
2.165561	2.039179	1.975516	1.731636	1.642851	1.693165	1.866082	1.868355	1.840574	2.436346	2.065274	2.065274

Sharpe Ratio Heatmap

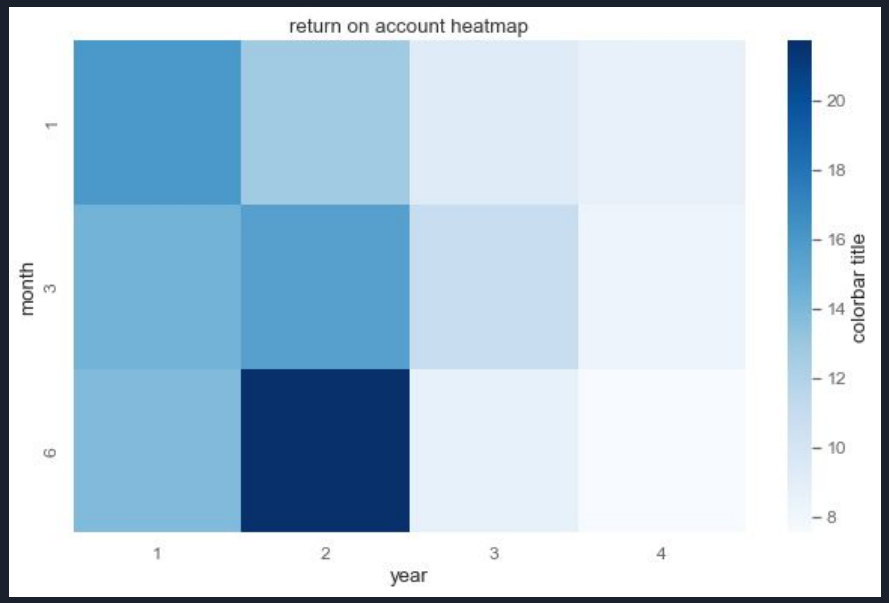


U.S. Soybean (SY)

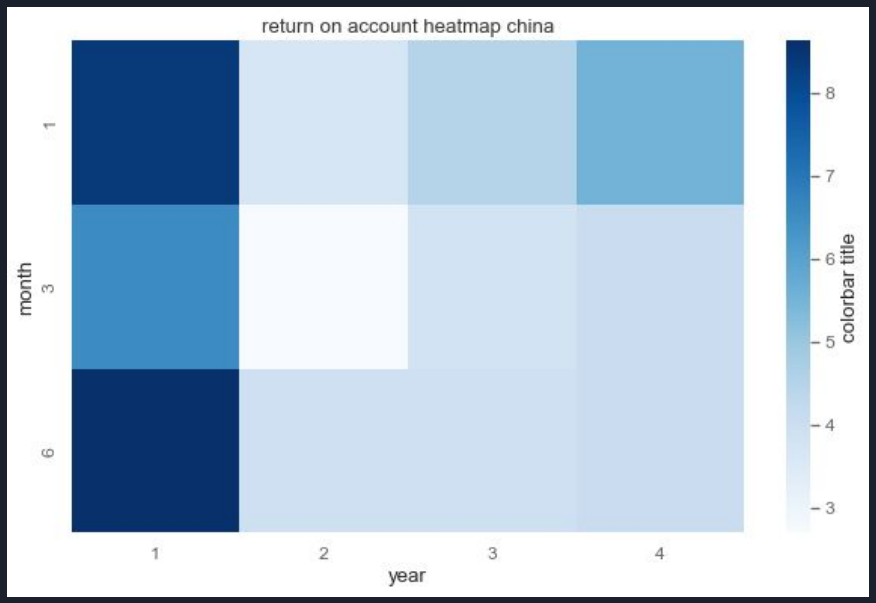


China No.1 Soybean (SOYBN)

Return on Account Heatmap

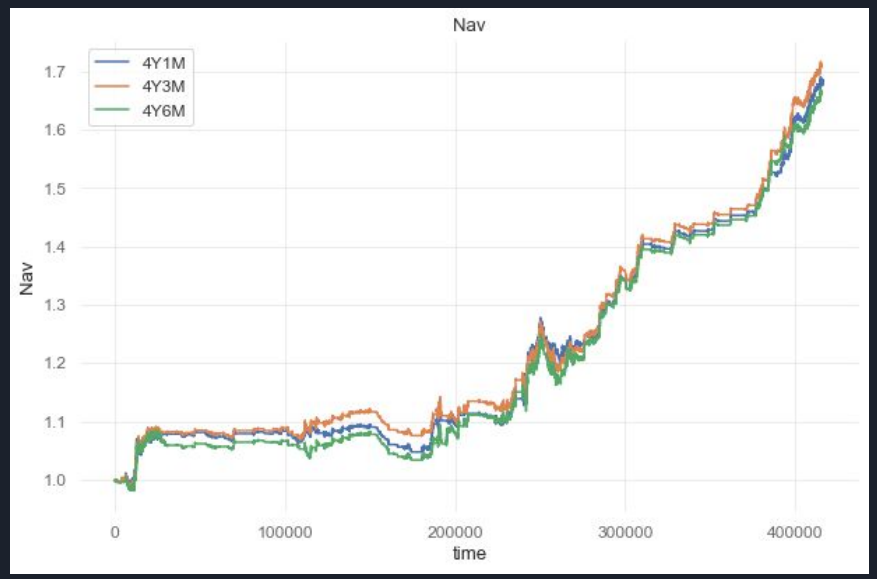


U.S. Soybean (SY)

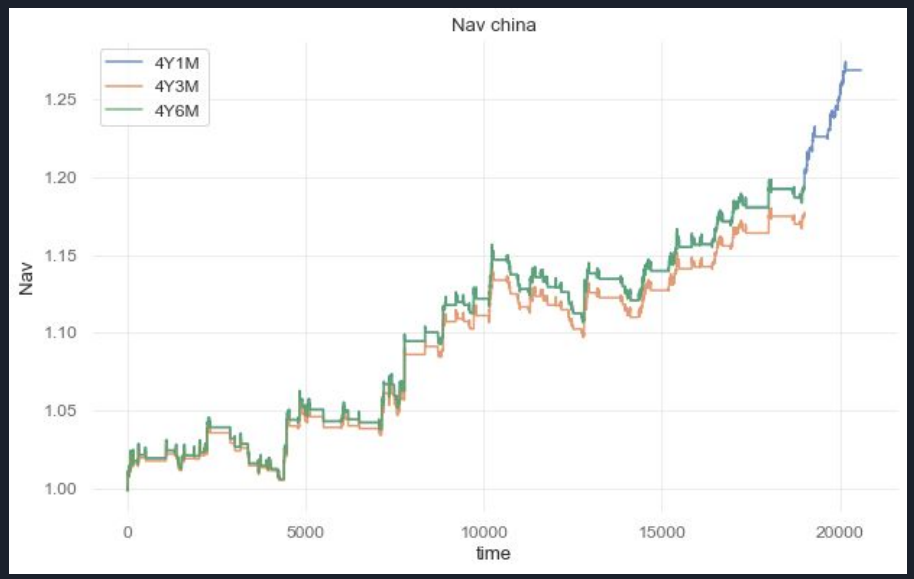


China No.1 Soybean (SOYBN)

Net Asset Value (Equity)



U.S. Soybean (SY)

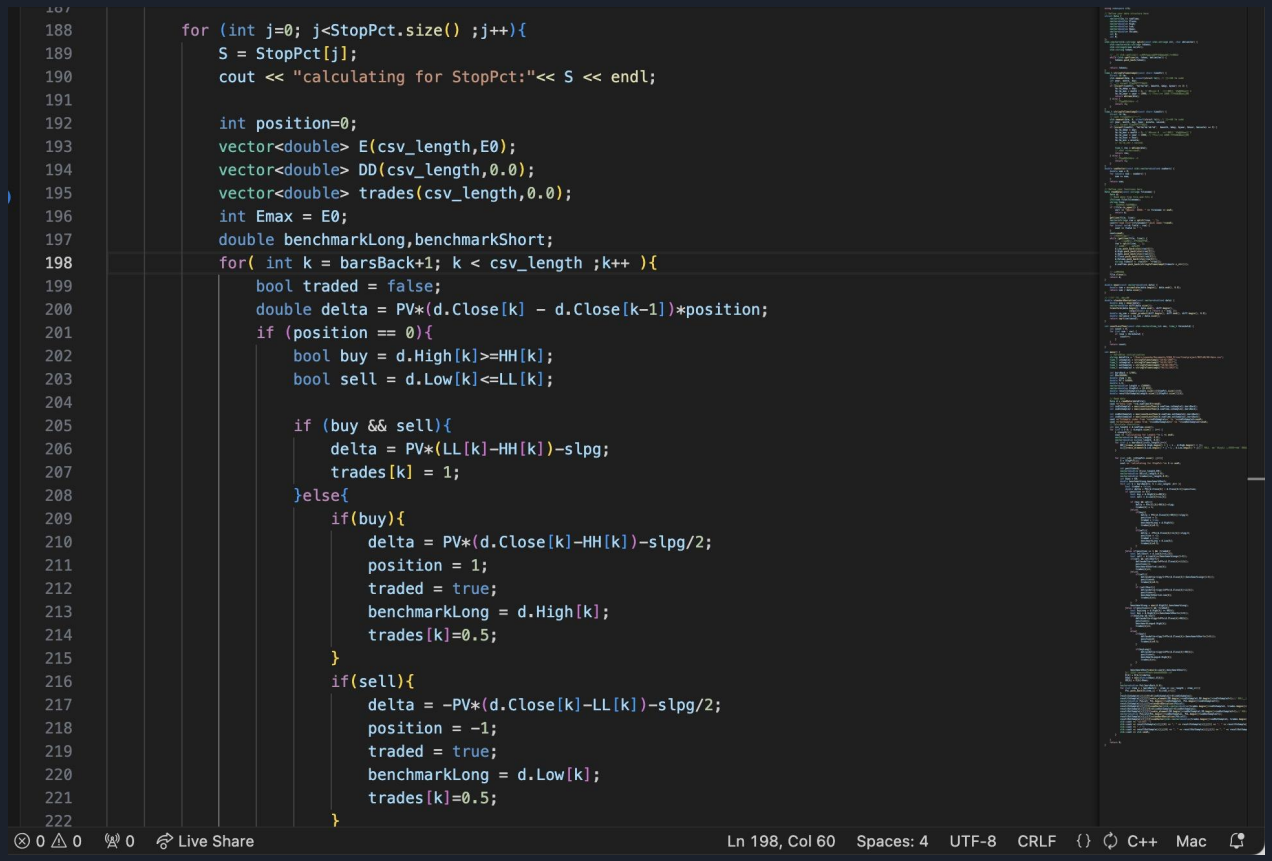


China No.1 Soybean (SOYBN)

Summary

- **Market Comparison:** While the U.S. provides stability, Chinese market offers higher profitability and a more dynamic environment.
- **Strategic Long Positions:** Initiating trades only during positive 'push' periods aligns with trend-following signals, enhancing profitability by capitalizing on upward market movements.

Coding-C++

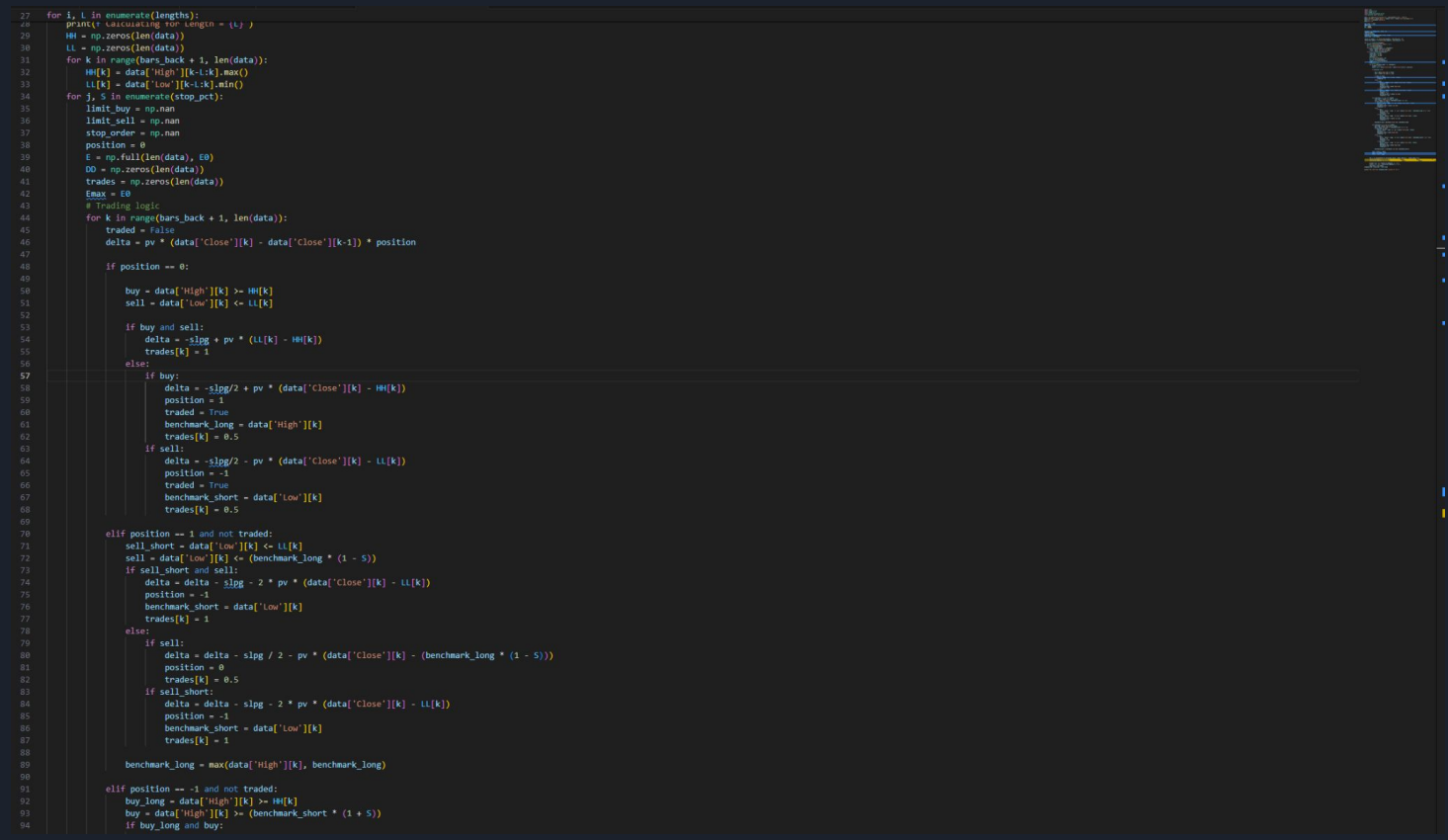


```
for (int j=0; j<StopPct.size() ;j++){
    S = StopPct[j];
    cout << "calculating for StopPct:"<< S << endl;

    int position=0;
    vector<double> E(csv_length,E0);
    vector<double> DD(csv_length,0.0);
    vector<double> trades(csv_length,0.0);
    int Emax = E0;
    double benchmarkLong,benchmarkShort;
    for( int k = barsBack+1; k < csv_length ;k++ ){
        bool traded = false;
        double delta = PV*(d.Close[k] - d.Close[k-1])*position;
        if (position == 0){
            bool buy = d.High[k]>=HH[k];
            bool sell = d.Low[k]<=LL[k];

            if (buy && sell){
                delta = PV*(LL[k]-HH[k])-slpg;
                trades[k] = 1;
            }else{
                if(buy){
                    delta = PV*(d.Close[k]-HH[k])-slpg/2;
                    position = 1;
                    traded = true;
                    benchmarkLong = d.High[k];
                    trades[k]=0.5;
                }
                if(sell){
                    delta = -PV*(d.Close[k]-LL[k])-slpg/2;
                    position = -1;
                    traded = true;
                    benchmarkLong = d.Low[k];
                    trades[k]=0.5;
                }
```

Coding-python(trading)



```python
for i, L in enumerate(lengths):
    print(f'Calculating for Length = {L}')
    HH = np.zeros(len(data))
    LL = np.zeros(len(data))
    for k in range(bars_back + 1, len(data)):
        HH[k] = data['High'][k-L:k].max()
        LL[k] = data['Low'][k-L:k].min()
    for j, S in enumerate(stop_pct):
        limit_buy = np.nan
        limit_sell = np.nan
        stop_order = np.nan
        position = 0
        E = np.full(len(data), E0)
        DD = np.zeros(len(data))
        trades = np.zeros(len(data))
        Emax = E0
        # Trading logic
        for k in range(bars_back + 1, len(data)):
            traded = False
            delta = pv * (data['Close'][k] - data['Close'][k-1]) * position

            if position == 0:

                buy = data['High'][k] >= HH[k]
                sell = data['Low'][k] <= LL[k]

                if buy and sell:
                    delta = -slpg + pv * (LL[k] - HH[k])
                    trades[k] = 1
                else:
                    if buy:
                        delta = -slpg/2 + pv * (data['Close'][k] - HH[k])
                        position = 1
                        traded = True
                        benchmark_long = data['High'][k]
                        trades[k] = 0.5
                    if sell:
                        delta = -slpg/2 - pv * (data['Close'][k] - LL[k])
                        position = -1
                        traded = True
                        benchmark_short = data['Low'][k]
                        trades[k] = 0.5

            elif position == 1 and not traded:
                sell_short = data['Low'][k] <= LL[k]
                sell = data['Low'][k] <= (benchmark_long * (1 - S))
                if sell_short and sell:
                    delta = delta - slpg - 2 * pv * (data['Close'][k] - LL[k])
                    position = -1
                    benchmark_short = data['Low'][k]
                    trades[k] = 1
                else:
                    if sell:
                        delta = delta - slpg / 2 - pv * (data['Close'][k] - (benchmark_long * (1 - S)))
                        position = 0
                        trades[k] = 0.5
                    if sell_short:
                        delta = delta - slpg - 2 * pv * (data['Close'][k] - LL[k])
                        position = -1
                        benchmark_short = data['Low'][k]
                        trades[k] = 1

                benchmark_long = max(data['High'][k], benchmark_long)

            elif position == -1 and not traded:
                buy_long = data['High'][k] >= HH[k]
                buy = data['High'][k] >= (benchmark_short * (1 + S))
                if buy_long and buy:
```

Coding-python(analysis)

```python
for i in file_idx:
    file_dict = dict()
    file_dict['nav'] = pd.read_csv('data/'+i+'/equity.csv', header = None)
    file_dict['trades'] = pd.read_csv('data/'+i+'/outputTable.csv', sep='\t')
    # file_dict['osp'] = pd.read_csv('data/'+i+'/outSampleParameters.csv', header = None, sep = '\t')
    file_dict['oss'] = pd.read_csv('data/'+i+'/outSampleStatistics.csv', sep = '\t')
    data_dict[i] = file_dict

for i in china_file_idx:
    file_dict = dict()
    file_dict['nav'] = pd.read_csv('data/china/'+i+'/equity.csv', header = None)
    file_dict['trades'] = pd.read_csv('data/china/'+i+'/outputTable.csv', sep='\t')
    file_dict['oss'] = pd.read_csv('data/china/'+i+'/outSampleStatistics.csv', sep = '\t')
    data_dict[i] = file_dict

#%%
'''
def for stats
'''

def ror(nav_lst):
    time_length = (nav_lst.shape[0]-1)*5/60/24
    return (nav_lst.iloc[-1,0] / nav_lst.iloc[0,0] - 1) * 252 / time_length

def vol(rtn_lst):
    return np.std(rtn_lst[0], ddof = 1) * (252 * 24 * 60 / 5)**0.5

def sharpe(nav_lst, rtn_lst):
    return ror(nav_lst) / vol(rtn_lst)

def num_trades(trades_lst):
    return trades_lst.shape[0]

def pct_winner(trades_lst):
    return trades_lst[trades_lst['Absolute_PnL']>0].shape[0] / num_trades(trades_lst)

def pct_profitable(trades_lst):
    return trades_lst[trades_lst['Absolute_PnL']>65].shape[0] / num_trades(trades_lst)

def mdd_scale(return_list):
    l = np.argmax((np.maximum.accumulate(return_list) - return_list) /np.maximum.accumulate(return_list))
    k = np.argmax(return_list[:l])
    return (return_list[k] - return_list[l])

def rtn_on_acct(nav_lst, oss):
    return np.nansum(oss['netProfit']) / abs(mdd_scale(np.array(nav_lst[0])))

def avg_winner(trades_lst):
    return np.nanmean(trades_lst[trades_lst['Absolute_PnL']>0]['Absolute_PnL'])
def avg_loser(trades_lst):
    return abs(np.nanmean(trades_lst[trades_lst['Absolute_PnL']<0]['Absolute_PnL']))

def profit_factor(trades_lst):
    return np.nansum(trades_lst[trades_lst['Absolute_PnL']>0]['Absolute_PnL']) / abs(np.nansum(trades_lst[trades_lst['Absolute_PnL']<0]['Absolute_PnL']))

#%%
'''
stats cal
'''
```

Coding-Java

```java
Double E0 = 200000.0;
int PV = 50;
int slpg = 65;
//iterate through each in-sample period
for (int i = finalInSampleStart; i <= finalInSampleEnd; i += outSampleMonth*22*apprNumberOfIntervals){
    inSampleStart = i;
    inSampleEnd = inSampleStart + inSampleYear*252*apprNumberOfIntervals;
    outSampleStart = inSampleEnd + 1;
    outSampleEnd = Math.min(inSampleEnd + outSampleMonth*22*apprNumberOfIntervals, totalLength - 1);//avoid IndexOutOfBo

    Double[] optParameters = {0.0, 0.0};
    optParameters = findOptimal2(slpg, PV, E0, dataList, ChnLen, StpPct, inSampleStart, inSampleEnd); //find optimal par
    System.out.println(optParameters[0] + " " + optParameters[1]);
    outSampleResult result = getOutSampleResult(slpg, PV, E0, dataList, optParameters, outSampleStart, outSampleEnd);//r

    //get out of sample satistics
    statistics.add(calculateStatistics(result.startDate, result.endDate, result.Absolute_PnL, result.DD, result.E));
    //add out of sample data into lists
    outSampleDateIn.addAll(result.Date_in);
    outSampleDateOut.addAll(result.Date_out);
    outSampleTimeIn.addAll(result.Time_in);
    outSampleTimeOut.addAll(result.Time_out);
    outSamplePriceIn.addAll(result.Price_in);
    outSamplePriceOut.addAll(result.Price_out);
    outSampleAbsolutePnL.addAll(result.Absolute_PnL);
    outSamplePercentPnL.addAll(result.Percentage_PnL);
    outSamplePositionBeforeExit.addAll(result.Position_before_exit);
    Equity.addAll(result.E);
    outSampleParameters.addAll(result.recordOptParameters);
    //update E0 after each trading period, next trading period will start from E0
    E0 = result.E.get(result.E.size() - 1);
}

//print out trade-by-trade table in terminal
ArrayList<String> writeOutList = new ArrayList<>();
String title = "Date_In\tTime_In\tDate_Out\tTime_Out\tPosition_Before_Exit\tPrice_In\tPrice_Out\tAbsolute_PnL\tPercent_P
writeOutList.add(title);
System.out.println("Date In\t\tTime In\t\tDate Out\tTime Out\tPosition Before Exit\tPrice In\tPrice Out\tAbsolute PnL\tP
for (int i = 0; i < outSampleDateIn.size(); i++) {
    String temp = String.format("%s\t%s\t%s\t%s\t%d\t%.2f\t%.2f\t%.2f\t%.5f", outSampleDateIn.get(i),
    outSampleTimeIn.get(i), outSampleDateOut.get(i), outSampleTimeOut.get(i), outSamplePositionBeforeExit.get(i), outSam
    outSamplePriceOut.get(i), outSampleAbsolutePnL.get(i), outSamplePercentPnL.get(i));
    writeOutList.add(temp);
    System.out.printf("%-10s\t%-10s\t%-10s\t%-10s\t%-20d\t$%-10.2f\t$%-10.2f\t$%-10.2f\t%-10.5f\n", outSampleDateIn.get(
    outSampleTimeIn.get(i), outSampleDateOut.get(i), outSampleTimeOut.get(i), outSamplePositionBeforeExit.get(i), outSam
    outSamplePriceOut.get(i), outSampleAbsolutePnL.get(i), outSamplePercentPnL.get(i));
}
```

https://drive.google.com/drive/folders/1Z2yQkCL_D-Ki8RYUP7rE_b_YfuVFnGiE?usp=drive_link

References

https://www.barchart.com/futures/quotes/XT*0/profile

https://www.barchart.com/futures/quotes/ZS*0/profile

https://www.cmegroup.com/markets/agriculture/oilseeds/soybean.contractSpecs.html